Manual of Rural Telephony

BY

J. A. WILLIAMS

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RURAL TELEPHONY

BY

J. A. WILLIAMS

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INTRODUCTION.

As its name implies this book is intended as an elementary and practical treatise on RURAL TELEPHONY. Its object is to enumerate and explain all of the necessary points to be considered in connection with the organization, construction, operation and maintenance of private lines, party lines, and rural telephone exchange systems.

The author has in mind the fact that most books on telephony treat the subject from an historical and theoretical rather than a practical standpoint. Therefore this book is illustrated with diagrams, cuts and descriptions of every principle and piece of apparatus involved that will contribute to the useful knowledge of the reader upon the subject of the work. It is divided into three parts.

Part One contains hints as to the benefits to be derived from the general use of telephones in rural districts and also as to the organization of individuals into co-operative or corporate bodies for the purpose of having and maintaining telephone communication.

Part Two treats of the construction and maintenance of rural telephone lines and the principles involved in line work, illustrated with the necessary diagrams and cuts.

Part Three is devoted to the principles of electricity as applied to telephony and to that class of telephones and telephone apparatus best suited to the requirements of Rural Systems.

The author would recommend, before beginning the study of this book, the careful perusal of Chapter Thirteen, Part Three, to thus become familiar with the electrical terms and phrases used herein as applied to telephony.

The author wishes to express his thanks to the following persons and firms for diagrams, cuts and illustrations that were kindly loaned him:—Electric Gas Lighting Co., Boston, Mass.;

American Electric Fuse Co., Chicago, Ill.; Mathias Klein & Son, Chicago, Ill.; Nungesser Electric Battery Co., Cleveland, Ohio; National Carbon Co., Cleveland, Ohio; The Williams Electric Telephone Co., Cleveland, Ohio; The North Electric Co., Cleveland, Ohio, and Geo. Worthington Co., Cleveland, Ohio.

The author also wishes to express his obligation to Mr. C. R. Underhill, E. E., for assistance with some of the data and diagrams.

If the substance of this book shall be of practical assistance to the rural telephonist, the author will be more than pleased with his work.

Sincerely yours,

J. A. WILLIAMS, E. E.

CHAPTER 1.

ADVANTAGES OF TELEPHONE SERVICE.

At the present time in nearly all cities and smaller towns of the United States, there are established and in operation telephone exchanges. While it may seem that a telephone exchange would be more needed in a city than in the country, still upon reflection one will see that there are many reasons why an isolated dwelling in a rural district should need a telephone more than a city home; as in all cities of any size, rapid communication by street railway and other means are provided. In a country district, however, where roads are bad in some seasons of the year and the distance between neighbors is considerable, a telephone is far more than a mere convenience. It is a necessity and is useful in many ways; to call a physician in time of sickness; to call for help in event of fire, accident or other distress; to transact general business, such as ascertaining the state of the market on different articles of produce or merchandise; to hire help, and to handle quickly many different affairs that come up daily in farm life. The telephone has all of these, as well as the social advantages to be derived by having every person in a community within instantaneous communication with every other. If high grade long distance bridging telephones are used and line connections are established, the farmer can talk from his home, many hundreds of miles away into the large business centers with just as much certainty and ease as the city merchant from his office.

As a financial or business proposition, the rural dweller cannot afford to be without a telephone and especially so where he owns his own telephone and builds his own line.

The expense of maintaining and operating a telephone system in a rural district is very slight and becomes less per subscriber as the number of members become greater. The author has in mind many communities where only twenty-five cents per month is paid into the treasury by each subscriber, this

amount being amply sufficient to pay the operators and maintain the central exchanges in first-class working order.

The usual rural telephone exchange is composed of one or more lines that average from ten to fifteen telephones on a line. These different lines center at small villages, cross-road stores or post offices where a small switchboard is placed and the person in charge of the store or office operates the switchboard when called. The different lines are run according to these small groups or centers so that any subscriber on any line or set of lines can get connection with any other subscriber on any other line or set of lines, as is shown by Fig. 1, which is a map of a rural telephone system.

THE MODERN "MAUD MULLER."

"Maud Muller, on a Summer's day,"
Was raking the meadow sweet with hay.
She glanced toward the West and heaved a sigh,
For threatening clouds hung in the sky.

She hurried home, for well she knew,
She had many friends both kind and true.
Her hay was in danger, she made it known
Over her father's telephone.

Her neighbors came and worked with a will,
The storm clouds lowered and threatened till,
With a flash of lightning and omnious roar,
The rain in torrents began to pour.

Maud Muller smiled, she had saved the day,
By saving her father's new mown hay.
Her friends rejoiced, but 'twas only done
Because in the house was a telephone.

MILLER.

MORAL—Get in line—a telephone line.

CHAPTER II.

ORGANIZATION.

An organization for the purpose of carrying on an independent telephone system, is by no means difficult to form. There are two kinds of organization, which the writer would suggest, either of which is suitable and effective for the above purpose, and each has its own peculiar advantages.

FIRST: A partnership may be formed by any number of individuals, and they can, by contract, stipulate and agree, each with the other faithfully to perform any and all lawful conditions which are set forth in their contract, and may provide therein as to duties, responsibilities, and liabilities; *but while dealing with persons not parties to the contract, each and all are liable to such persons for the actions and contracts of their partners.*

SECOND: A corporation is an artificial being created by law and composed of individuals who subsist as a body politic, under a special denomination, with a capacity of perpetual succession and of acting within the scope of its charter as a natural person. The parties interested in this form of organization are known as stockholders, whose business is usually directed and controlled by a board of directors elected by such stockholders and who act in the capacity of trustees for the benefit of all stockholders. Such organizations, in addition to their Board of Directors, generally have a President, Vice-President, General Manager and a Secretary and Treasurer, whose duties are prescribed by the Constitution and By-Laws of the corporation. The various states of the union issue such charters and some are much more liberal than others in the conditions upon which such charters are issued. As an illustration of this difference: the laws of many of the states impose no stockholders' liability. This stockholders' liability imposed by many states, means that a party holding stock in a corporation is liable to the creditors in an amount equal to the face value of the shares of stock held by him. This burden, however, is only to be considered if the general assets of the corporation are not sufficient to pay its debts

CONSTITUTION FOR A TELEPHONE ASSOCIATION.

In Organization No. 1, which is a mere partnership or association, the general form of constitution and by-laws is herewith given. Of course any by-laws that are applicable to the particular situation can be substituted for the ones herein mentioned.

1st. The name of this association shall be and is..... Telephone Association.

2nd. The object of this association is and will be to establish and maintain a telephone exchange system for the purpose of facilitating telephone communication between its members and the members or subscribers of other telephone associations or systems.

3rd. The officers of this association shall be as follows: A President, a Secretary and a Treasurer.

4th. These three members when elected shall and do constitute an executive committee whose duties embrace the purchase of telephone instruments, supplies and materials, the arranging of right-of-ways, collection and disbursement of funds and all business of whatever nature that it may be necessary for the association to transact.

5th. This executive committee shall hold regular monthly meetings and may arrange to hold meetings oftener as necessity demands. The work may be divided among themselves as best suits their own convenience.

6th. The President of the Association is to preside at all meetings of members or subscribers. The Treasurer is to collect, disburse and be liable for all funds. The Secretary shall look after all statistics and shall keep a record of all proceedings of all meetings in the form of a minute book.

7th. The executive committee or any two members thereof may call a general meeting of the members of this association at any time by giving to each member forty-eight hours' notice by telephone or otherwise.

8th. A two-thirds majority of the executive committee constitutes a quorum and a two-thirds vote of those present is necessary on any question in order to carry it.

9th. One-half of all the shareholders or subscribers to this association shall constitute a quorum and two-thirds of all the members present at any meeting containing a quorum, shall constitute a working majority.

The subscribers or members of this association shall and do have the right at any regular or advertised meeting to pass by-laws governing the executive committee in their general transactions and governing all members in connection with the general affairs of the association. The regular annual meeting of the members of this association shall be on (date) of each year. This constitution may be altered, amended or changed at any time by a two-thirds vote of all of the members of this association. Any member of this association has the right to be represented in a general meeting of the members of the association by proxy.

BY-LAWS FOR A TELEPHONE ASSOCIATION.

1st. Any new member coming into this association shall sign and assent to all of the provisions of the constitution and by-laws of this association before becoming a member thereof.

2nd. The signers of this article each agrees to pay into the hands of the Treasurer the sum of $.....as a membership fee, such sum to be expended for the purpose of purchasing telephones, line supplies and all necessary appurtenances to the carrying out of the object of this association.

3rd. Should the amount so paid by each member be insufficient, each and every signer hereto agrees to pay his or her pro rata share of whatever amount is necessary.

4th. If the amount subscribed and paid in as above should be more than necessary, the Treasurer shall reimburse each individual to the extent which he or she shall have over-paid.

5th. Each subscriber agrees to pay into the hands of the Treasurer .....cents monthly in advance (usually from 15 to 25 cents per month per member) for the purpose of maintaining the central exchanges, paying the operators and all other necessary incidental expenses, such as repairing the lines, switchboards and for the general purpose of maintaining the entire system in a first-class manner.

6th. No subscriber shall connect to the line any piece of apparatus or at any time tamper with the lines of the association.

7th. The executive committee shall have the right to disconnect permanently from the lines of the association any subscriber who maliciously and wilfully tampers with the lines of the company with the object and purpose of injuring the service.

8th. Each subscriber shall be charged with the expense necessary to maintain his own instrument in first-class working order, such as battery renewals, incidental burn-outs, etc., and damage from lightning or any other source.

9th. The executive committee is hereby authorized to purchase and keep on hand at some convenient place such supplies

as batteries, ringer coils or parts of telephones or switchboards and to sell them to the members of this association at their first cost.

10th. The lines, instruments, switchboards and right-of-ways and all appurtenances to this system are the property of the association as a body and no part of it is the property of any individual member of this association.

11th. When any two subscribers are using any line they have the right-of-way over that line for five minutes, if transacting business, before any one else has a right to cut in on them without their consent.

12th. We, the following signers of these articles of association, do hereby agree to the constitution and by-laws of this association and we do hereby further agree to be bound in every way by the will of the majority.

Signatures.

.....
.....
.....

Witnesses.

.....
.....

In Organization No. 2, which is a regular incorporation, the general form of articles of incorporation, constitution and by-laws are herein given.

ORGANIZATION NO. 2.

This is a regular incorporated stock company for profit.

FORM OF ARTICLES OF INCORPORATION FOR A TELEPHONE COMPANY.

These articles of incorporation of the.....Telephone Company, WITNESSETH:—That we, the undersigned, (all or a majority) of whom are citizens of the State of....., desiring to form a corporation for profit under the general incorporation laws of the said state, do hereby certify:—

First: The name of said corporation shall be the..... Telephone Company.

Second: The said corporation is to be located at..... in.....County.....State and its principal business there transacted.

Third: The said corporation is formed for the purpose of constructing, building or acquiring by purchase or otherwise telephone instruments, lines, exchanges and equipments for the purpose of giving telephone service to the subscribers of the system and others, and all things that are incidental to the carrying on of the purposes of this corporation as aforesaid.

Fourth: The capital stock of said corporation shall be ($10,000.00) divided into 1000 shares of $10.00 per share.

IN WITNESS WHEREOF, we have hereunto set our hands this.....day of.....A. D., 19.....

.....

.....

(Signatures of Incorporators.)

FORM OF ACKNOWLEDGMENT OF ARTICLES OF INCORPORATION.

State of..... } ss.
County of..... }

Personally appeared before me, the undersigned, a notary public in and for said county, this.....day of.....A. D., 19....the above mentioned parties (here insert the names of the incorporators) who each and severally acknowledged the signing of the foregoing articles of incorporation to be his free act and deed for the uses and purposes therein mentioned.

WITNESSETH, my hand and official seal on the day of the year last aforesaid.

.....

Notary in and for said County.

(NOTE)

Some of the states require a certificate from the Clerk of the Common Pleas Court to be attached to the articles of incorporation.

FORM OF SUBSCRIPTION TO CAPITAL STOCK.

.....City.....State.....19.....

We hereby severally subscribe to the capital stock of the .....Telephone Company the number of shares written opposite our respective names and agree to pay therefor the sum of ($).....per share.

Signatures:

.....
.....
.....

FORM OF CERTIFICATE OF STOCK.

Number..... .....Shares.

STATE OF.....

The.....Telephone Company.

Capital Stock $10,000.00. Shares $10.00 per share.

This certifies that.....is entitled to..... shares of the capital stock of the.....Telephone Company, which are transferable only on the books of said company by the said stockholder, or his representative or attorney, on the surrender of this certificate.

Dated at....., this.....day of....., A. D., 19.....

.....
President.

(Seal of incorporation)

.....
Secretary.

‡Indorsement-assignment:

For value received, ...hereby sell, assign and transfer to.....shares of the stock within mentioned, and authorize the Secretary to make the necessary transfer on the books of the company.

Dated at....., this.....day of....., A. D., 19.....

‡(This is usually printed on the back of certificate of stock.)

FORM OF CONSTITUTION AND BY-LAWS.

ARTICLE I.

Name, Shares and Seal.

Sec. 1. The name of this incorporation shall be....., incorporated under the laws of the State of..... on the.....day of....., A. D., 19...., for a period of.....years, for the purpose of.....with the principal offices located at....., State of.....

Sec. 2. The capital stock of this corporation shall be..... Dollars, divided into.....shares of..... Dollars each, which shall be full paid and non-assessable.

Sec. 3. The corporate seal of this corporation shall contain the full corporate name of this corporation, with the principal office and state in the outer circle. Within the circle there shall be the words "Incorporated" with the month, day and year.

ARTICLE II.

STOCKHOLDERS' MEETING.

Sec. 1. The annual stockholders' meeting of this corporation shall be held at the general offices of the corporation in the city of.....on the.....day of.....A. D., 19...., annually at the hour of.....o'clock, ...m. Providing that when said day shall fall on Sunday or a legal holiday, such meeting shall be held on the previous day at the same hour and place.

Sec. 2. Special meetings of the stockholders may be called by stockholders representing two-fifths of the stock issue, filing with the Secretary a written call for such meeting, stating the object and hour. Such meeting shall be held at the regular place.

Sec. 3. At all stockholders' meetings each stockholder shall be entitled to cast one vote for each share of stock held or owned.

This vote may be cast in person or by proxy appointed in writing duly filed with the Secretary, and by him entered on record in the minutes of the meeting.

Sec. 4. A quorum shall consist of a majority of the shares of stock represented by stockholders present and voting. But stockholders representing less than a quorum of stock may adjourn the meeting to a future day.

Sec. 5. The President and Secretary of the corporation shall act in their official capacity at all stockholders' meetings.

Sec. 6. The Secretary shall mail to each stockholder at his last known place of residence a written or printed notice of the time and place of holding each annual or special meeting. Such notice shall be mailed.....days prior to the date of meeting.

ARTICLE III.

DIRECTORS AND MEETINGS.

Sec. 1. The affairs of this corporation shall be controlled and managed by a board of.....directors, who shall be elected by the stockholders at the annual meeting, and shall hold office for one year or until their successors shall have been elected and qualified.

Sec. 2. No person shall be elected a director who is not a stockholder in the corporation.

Sec. 3. Vacancies in the board of directors may be filled by a majority of the remaining members at any directors' meeting regularly called.

Sec. 4. The directors shall elect all the other officers of the corporation, and may appoint during their pleasure a superintendent.

Sec. 5. The transfer of all the stock owned by a director shall operate as a resignation of office.

Sec. 6. Regular meetings of the board of directors shall be held immediately following the adjournment of the stockholders' annual meeting, and also on the first Monday of each month at the hour of.....o'clock.....m. Such meetings shall be held in the general office of the corporation.

Sec. 7. Special meetings of the board of directors may be called at any time by the President, and in his absence by the Secretary on application in writing, by a majority of the direc-

tors, by mailing to each director, at least.....days prior to the date of such meeting, a written or printed notice stating time and place of holding said meeting.

Sec. 8. At each annual meeting of the stockholders the directors shall present a general statement of the business of the preceding year, a report of the financial condition of the corporation, and a report of the condition of the plant.

Sec. 9. No sale, lease or mortgage of any part or all of the property or property rights either tangible or intangible or of any franchises or right-of-ways of this corporation shall be made without the full consent in writing of four-fifths of all of the stockholders of this corporation, obtained either at any regular annual stockholders' meeting or at a special meeting called for that purpose.

Sec. 10. A quorum of directors shall consist of a majority of the directors. But a smaller number may adjourn to a subsequent time.

ARTICLE IV.

OFFICERS.

Sec. 1. The elective officers of this corporation shall be a President, Vice-President, Secretary and a Treasurer, who shall perform the usual duties appertaining to their respective offices, and who shall be elected by the directors at a meeting subsequent to the annual meeting, and immediately following its adjournment. They shall hold office for one year, and until their successors are elected and qualified.

Sec. 2. The directors may by resolution require any or all of said officers to give bonds to the corporation, with good and sufficient surety conditioned for the faithful performance of their respective duties and offices.

Sec. 3. The yearly salaries of the officers of this company are hereby fixed as follows:

President $.....; Vice-President $.....; Secretary $.....; Treasurer $.....; General Manager $..... Said salaries shall be payable monthly on the first day of each month.

Sec. 4. All directors and executive officers of the corporation must be holders of at least one share of stock.

Sec. 5. No person shall be elected to the office of President or Vice-President who is not a director of the corporation.

6. When the President or Vice-President ceases to be a director of the corporation, he or she shall cease to be President or Vice-President, and the office is declared vacant, and a new President or Vice-President is elected.

ARTICLE V.

STOCK.

All certificates of stock shall show the name of the corporation, the capital stock, the par value of shares, to whom issued, the number of shares in each certificate, and shall be signed by the President and Secretary and sealed with the corporate seal.

Sec. 2. Shares of stock must be transferred upon the books of the corporation either in person or by attorney upon surrendering the certificate to the Secretary for cancellation, and signing such transfer in the regular transfer book of the corporation. Whereupon a new certificate shall be issued to the party becoming the new stockholder.

Sec. 3. The board of directors may by resolution order the transfer of stock to stop for a space of time not exceeding thirty days immediately before the time a dividend is payable, or before the regular meeting of the stockholders.

Sec. 4. Upon the failure of any stockholder or subscriber to pay the amount subscribed or any assessment of such amount levied on his stock for thirty days after the same shall become due, the Secretary shall cause a written or printed notice to be served personally on such stockholder or subscriber, or to be sent to him or her by registered mail. Such notice shall state the amount due from such stockholder or subscriber, and shall state that unless payment of the same is made within thirty days after the service or receiving of said notice, the stock subscribed for by him or her will be forfeited to the corporation. And if the delinquent stockholder or subscriber fails to pay the entire amount due within the time specified in such notice, his stock shall become forfeited without further action on the part of the corporation. And such forfeited stock may thereupon without further notice be sold by the corporation at either public or private sale. (Provided that the proceeds of such sale, if any, over

and above the amount due on such stock shall be paid on demand to the delinquent stockholder.)

ARTICLE VI.

AMENDMENTS.

Sec. 1. These by-laws or any part of them may be abridged, altered, or amended, added to, or repealed by the same body which enacted them at any regular meeting of such body.

—:—:—:—:—:—:—

Below is given a general idea of the usual form of conducting stockholders' and directors' meetings and a record of the minutes of the stockholders' meeting to elect the first board of directors and also minutes of the first board of directors to elect officers, etc.

RECORD OF MINUTES OF.....

meeting of the.....of the.....
held by order of.....at.....19....
.....
.....
.....
.....

THE MINUTES OF CORPORATION MEETINGS

are what is known as the corporation's record, and consist of the following headings:

First: The petition to the Secretary of State for license to organize.

Second: License by Secretary appointing commissioners to have the stock subscribed with their report to the Secretary of State in full, including the subscription list in full.

Third: Copy of the charter.

Fourth: Minutes of the first or original stockholders' meeting.

Fifth: By-laws and amendments thereto.

Sixth: Minutes of all meetings whether they be stockholders' or directors' in chronological order.

MINUTES OF A STOCKHOLDERS' MEETING

(To elect their first board of directors.)

A meeting of the stockholders of the.....was held at the office of.....in the.....of the County of .....and State of.....on the.....day of..... A. D. 19....at....o'clock....m., and within.....days after .....the Articles of Incorporation, and in pursuance of .....notice in writing, concerning the holding of this meeting and place first above mentioned, for the purpose of electing a Board of Directors.....and the transaction of such other business as may come before them, a copy of said..... notice appearing on page....of this book, as part of the Records of said Corporation.

Whereupon....., one of the subscribers to the capital stock of this corporation called the meeting to order and stated its object.

On motion duly made and carried.....was elected chairman of this.....stockholders' meeting, and on motion duly made and carried.....was elected Secretary. Each accepted their respective offices and discharged their duties until the close of the meeting.

The subscription list being then presented, exhibited and read, showed the following to be the subscribers to the capital stock of said corporation, to-wit:

.....subscribed for.....shares amounting to $.....
..... " " ..... " " " $.....
..... " " ..... " " " $.....
Total Shares Total $

Showing the capital stock of said corporation to be fully subscribed.

On the call of the roll of stockholders, by the Secretary, each of the before named stockholders voting the shares set opposite his name, answered "present".....showing the total number of.....shares, constituting a majority, being present.

At the close of the roll call the Chairman declared that .....shares of the capital stock was represented, and that the meeting was competent to proceed with the transaction of the business for which it was called.

The Chairman then stated that the articles of incorporation had been received and were in the hands of the Secretary, to be exhibited for the benefit of the stockholders.

The Chairman then instructed the Secretary to read that part of the Articles of Incorporation referring to directors.

On motion duly made and carried, the stockholders proceeded to the election by ballot of.....Directors..... to serve for the term of.....years.....or until their successors are elected and qualified.

On motion duly made and carried, that the Chairman appoint.....inspector.. to receive and count the votes to be cast for directors. Whereupon..... was appointed to act as such inspector.

Thereupon nominations having been made for directors, an election was held by ballot; the inspector..received and counted the ballots or votes cast, and announced that there were..... shares in all voted, being.....of the subscribed shares of the corporation, that.....shares were necessary to a choice, and that the following persons had been chosen as directors.....and that each had received the requisite number of votes.

Thereupon the Chairman declared such persons to be the duly elected Board of Directors of this corporation, to serve for the term for which they were severally elected, or until their successors are elected and qualified.

On motion duly made and carried, it was by a.....vote, RESOLVED, That the directors assess upon each share subscribed to the capital stock of this incorporation the sum of .....and that the same shall be payable to the Treasurer at a time to be named by said Directors.

On motion duly made and carried, the foregoing minutes were then and there read and approved.

On motion duly made and carried, the meeting was adjourned.

A TRUE RECORD.

Signed.....
Chairman.

Attest:
.....
Secretary.

MINUTES FIRST MEETING OF DIRECTORS.

(To Elect Officers, Etc.)

Immediately following the adjournment of the first meeting of the stockholders of the.....held this.....day of .....A. D., 19...., the Board of Directors of said corporation elected at said meeting, assembled at the office of .....at.....in the State of.....on .....the.....day of.....A. D., 19....at..... o'clock.....M, whereupon the meeting was called to order by .....and its objects stated.

On motion duly made and carried.....was elected Chairman and.....was elected Secretary of the meeting, each accepting the office and discharging its duties.

The Chairman then instructed the Secretary to read the list of Directors and the following Directors were found to be present, to-wit:

.....

There being a quorum present, on motion the board proceeded to the election of permanent officers of the corporation, viva voce, to serve for the ensuing year.

On motion duly made and carried.....was, by a unanimous vote, elected to the office of President of the corporation for the ensuing year, and was so duly declared.

On motion duly made and carried.....was, by a unanimous vote, elected to the office of.....Vice President of the corporation for the ensuing year and was so duly declared.

On motion duly made and carried.....was, by a unanimous vote, elected to the office of Secretary of the corporation for the ensuing year, and was so duly declared.

On motion duly made and carried.....was, by a unanimous vote, elected to the office of Treasurer of the corporation for the ensuing year, and was so duly declared.

On motion duly made and carried, the salary of the President was fixed at.....Dollars per annum, all of the Directors present at said meeting (except the President) voting for and in favor of such compensation.

On motion duly made and carried, the salary of the Secretary was fixed at.....Dollars per annum for the ensuing

year, all of the Directors present at said meeting (except the Secretary) voting for and in favor of said motion.

On motion duly made and carried, the following Resolution was adopted:

RESOLVED, That a seal in the form and having the words .....shown by the impression thereof on the margin hereof, be and the same is hereby adopted as the corporate seal of this incorporation, and the Secretary of this incorporation is hereby authorized and instructed to impress the same upon the margin of the page of the minute book upon which this resolution may be recorded, for the purpose of the future identification of said seal.

On motion duly made and carried, the following Resolution was adopted:

RESOLVED, That a certain blank "Certificate of Stock" identified by the impression of the corporate seal of this incorporation impressed thereon and having the words "Form of Certificate," "Cancelled,".....A. D., 19...., written in red ink across the face thereof, be and the same is hereby adopted and declared to be the form and device of the Certificate of Stock to be issued to the subscribers to the capital stock of..... and the Secretary is hereby directed to attach said form of Certificate to the page of the minute book on which this Resolution may be recorded.

On motion duly made and carried, a committee consisting of.....was appointed to consider and prepare a code of by-laws for the government of the affairs of this corporation, and present the same to the Board of Directors for their consideration at the earliest possible moment.

On motion duly made and carried.....was designated as the office of the principal place of business of the corporation.

On motion duly made and carried, the.....day in each month at.....o'clock....M., was fixed as the day and hour upon which the regular monthly meetings of the Board of Directors of.....would be held during the ensuing year.

On motion duly made and carried, the following Resolution was adopted:

RESOLVED, That the Treasurer be and hereby is directed to execute and deliver to this corporation a bond in the sum of

.....Dollars, with.....sureties, to be approved by this board, conditioned that he will faithfully account for all moneys that may come into his hands as such Treasurer, and that he will faithfully perform the duties of his office as required by the Board of Directors or by the rules and by-laws of this corporation.

On motion duly made and carried, the following Resolution was adopted:

RESOLVED, That the sum of.....Dollars on each and every share subscribed to the capital stock of this corporation be and the same is hereby ordered to be paid to the proper officers of said corporation by the subscribers thereof respectively, on or before the.....day of.....A. D., 19....

The committee to whom had been committed the matter of by-laws for the government of the affairs of the corporation presented its report, with a code of by-laws, which having been read and discussed at length by the several Directors comprising the board, this code of by-laws was, on motion duly made and carried, adopted and ordered spread at length on the minute record of the corporation and the committee discharged.

On motion duly made and carried, the Secretary was instructed to file the charter, or articles of incorporation, for public record, in accordance with the law in such cases made and provided.

On motion duly made and carried, the Secretary was instructed to procure, at the expense of the corporation, necessary stationery, account books, papers, etc.

On motion duly made and carried, the Secretary was instructed to draw an order on the Treasurer for the payment of all bills for the expense of incorporating, for the seal, certificates of stock and records incidental thereto.

On motion duly made and carried, the meeting adjourned.

A TRUE RECORD.

Signed.....

Attest:—

.....Sect.

COMMENTS ON THE DIFFERENT FORMS OF ORGANIZATION.

In starting a small telephone system, embracing but one or two lines with 15 or 20 subscribers each, it would probably be better to organize similarly to Organization No. 1, that is, a mere association of individuals into a kind of general partnership for the purpose of securing telephone communication. As the business grows larger and other lines start up and wish to be connected, it would probably be found better to organize into a regular stock company for profit. It might also be a good idea to sell stock only to the subscribers of the different lines or to those who wish to become subscribers so that the telephone company may be owned entirely by its subscribers and patrons. In this way, whatever profits there are will be paid back to the subscribers of the company, which will reduce the net cost of their telephone service, thus making the system somewhat in the nature of a co-operative telephone company. All of the subscribers will, in this way, be sure of getting the full value of the money expended for telephone service. The telephone itself is a very important factor in any community and especially in a rural district. It has not progressed very satisfactorily under the old monopoly, whose rates were so exorbitant and service so poor, that a telephone was considered but as a luxury for those who could afford it. Now, every fundamental patent controlling the principle of telephones and their use has either expired or been set aside by the United States Supreme Court as invalid. Consequently, nothing prevents citizens from going into the telephone business on their own account and securing all of the many benefits to be derived from having universal telephonic communication with each other.

Where telephone properties are owned by others than the subscribers, of course it is to their interest to make a profit on giving telephone service and they are expected to do so. It is impossible for companies whose stockholders are not subscribers to give as good service for the same money or at as low

rates, as telephone companies who do not operate for profit or who pay the profits back to their subscribers in dividends.

With telephones, as with all other necessities, there has been a constant effort and probably always will be, to control telephone service by monopolies so as to make large profits.

It is the opinion of the author that inasmuch as the telephone is just as much of a necessity as a sewing machine or a farm vehicle that it ought to be owned and controlled by him who uses it—the citizen; and he may rest assured that no one else can or will give him as good service as he can give himself, or at as low rates for service.

Where the subscriber is a stockholder and where all own individually the same amount of stock, then whatever the profits, they are equally distributed among the stockholders in proportion to the amount they contribute, which is eminently just and must be satisfactory.

CHAPTER III.

COST OF RURAL TELEPHONE INSTALLATIONS.

We will first estimate the cost on one line of 25 subscribers, 12½ miles in length, without a switchboard connection at either end. This is what is called a party line. The kind of wire we will figure on is No. 12 (Birmingham Wire Gauge) B. B. galvanized steel telephone wire. This wire has a weight of 165 lbs. per mile and for the 12½ miles would contain a total weight of 2,063 lbs., which at the present market price of 3¾c. per lb., would be about $77.44 cost for the line wire. With 20 poles per mile, which makes very good construction where but one wire goes on one set of poles, the entire line of 12½ miles would require 250 poles at a cost of about 50c. per pole for cutting, trimming and delivering, which would make $125.00 for the cost of the poles. It would require a bracket and pony glass insulator for each pole. The average market price of insulators at present is 2½c. each and brackets 1½c. each, which would make an additional cost for material of 4c. per pole, which would be $10.00 for brackets and insulators for the entire line. With high grade 3,500 Ohm bridging telephones, at an estimated cost of $14.00 each, the 25 telephones would cost $350.00. The cost of labor of setting the poles, stringing the wire, making ground connections and installing the system is a matter that can hardly be estimated, as these figures vary so much in different localities. Work of this kind in the country usually may be done during some dull season when time is not worth very much. We will assume certain figures, however, as to the cost of labor so as to get a complete estimate.

Setting 250 poles at 15c. each would cost	$34.50
Making ground connections at the different houses, 10c...	2.50
Placing wire and tying it upon insulators for the total 12½ miles	10.00
Placing and connecting up instruments, 25c. each	6.25

Summing up the whole cost of the different items we have as follows:

Cost of wire	$ 77.34
Cost of poles	125.00
Cost of insulators and brackets	10.00
Three doz. porcelain knobs for house connection	.36
Telephones	350.00
Total cost of material	$562.70
Labor on setting poles	$ 34.50
Making ground connections	2.50
Stringing wire	10.00
Delivering and connecting up 'phones	6.25
Cost of labor	$ 53.25
Cost of material	562.67
Total cost labor and material	$615.82

This amount divided by the 25 subscribers makes the estimated cost per subscriber $24.51, which includes all labor and material necessary. If the material only is to be figured, as in some cases, the citizens construct lines themselves, it will, of course, further reduce the cost to about $22.51 per each subscriber. This includes paying $5.00 per subscriber for poles. Where the poles are furnished without cost by the different members a further reduction results, making the net cost about $17.50 per subscriber. This is figuring on having the members average about one-half mile apart. Where they average further apart, it would simply add to the cost in proportion to the cost of the line per mile. The total cost of the line per mile without figuring labor on installing telephones is for:

The poles	$10.00	per mile
No. 12 B. B. wire	6.19	per mile
Brackets and insulators	.80	per mile
Cost of line material	$16.99	per mile
Labor for setting poles	$ 3.00	per mile
Stringing wire	.80	per mile
Total cost of labor and material	$20.79	per mile

Now, with these figures as a basis the cost can be readily calculated where the subscribers are further apart or nearer together than one-half mile average distance such as we figured upon.

By this way of figuring we have an average cost in round numbers of twenty-five dollars per subscriber, including labor, materials, telephones and everything complete, for average rural telephone systems. This is figured on the basis of using No. 12 B. B. steel telephone wire with ground return and the highest grade of bridging telephones which, of course, render the best service. It is hardly necessary or advisable to use metallic circuit for rural telephone systems, as metallic circuit construction requires the poles to be set closer and considerable additional line expense, which would increase the first cost so as to be prohibitive to a great many citizens. Inasmuch, as the value of a telephone depends almost entirely upon the number of people that can be reached, it is, therefore, advisable to use that system which will reach, on account of its low first cost, the greatest number of people and will give service sufficiently good for all practical purposes.

Where long distance talking is to be done, a repeating coil can be used on the switchboard which connects with the long distance metallic circuit line. This will in virtue have the effect of transferring the voice currents from the grounded circuit lines to the metallic circuit lines, without in any way causing interference between the two different systems, that is, the grounded and metallic circuit system.

The very best grade of telephones ought to be used, however, as the very best grade costs but slightly more than the poorer kinds and there is such a vast amount of superiority in the quality of service they render both as to talking and ringing.

Referring again to Fig. 1 on Page 32, you will find a map of a rural telephone system comprising 175 telephone subscribers and three switchboards connected by wires that have no other subscribers on them. The different switchboards we will designate as being located in the villages A., B. and C. In village "C" there is a metallic circuit line, which is shown by dotted lines running out to a larger town where connections are made for long distance talking. A repeating coil is used on the switchboard at "C" which practically has the same effect as

though all of the lines in the rural telephone system were metallic circuit. These repeating coils are not very expensive, and as but few of them have to be used, it is better to use one or more repeating coils than to make the entire system metallic circuit.

To figure operating expenses on the system as shown by map in Fig. 1, there are three switch tenders, who, we will assume, are located in stores and take care of the switchboard in addition to their other duties. We will assume their pay to be in "A" (which has the largest number of subscribers) $10.00 per month, and in "B" $5.00 per month, and in "C" $5.00 per month, making $20.00 per month for operating expenses, to be divided up among the entire 175 subscribers. We will assume that each subscriber pay 20c. per month for service. This would amount to $35.00 per month, which would leave $15.00 per month over and above the actual operating expenses to go into the general treasury to take care of the repairs and other incidental expenses.

COST OF TELEPHONE EXCHANGES IN TOWNS OF FIVE THOUSAND POPULATION AND UNDER.

The difference between installing rural exchanges and city exchanges is usually in the lines that are run. In village or city exchanges, it is customary to give to each subscriber an individual line and an individual switchboard drop. As none of the members are very far from the Central exchange, it does not take any more, or hardly as much, wire to give to each user a separate line as it does to put a number of subscribers on one line in a rural system. The poles that are used, however, in cities must be larger and more substantial than those of rural lines, as they have to carry a larger number of wires and be tall enough to hold the wires clear of other wires and tree tops. The lines should be high enough above the sidewalk to present a sightly appearance. The poles usually used are 40 feet long, 8 inches in diameter at the top and are set about five feet in the ground. The wires are placed on crossarms and aerial lead covered cable is employed to bring the wires from the cable pole into the exchange.

The cost of the average system of from one to five hundred subscribers is about as follows:

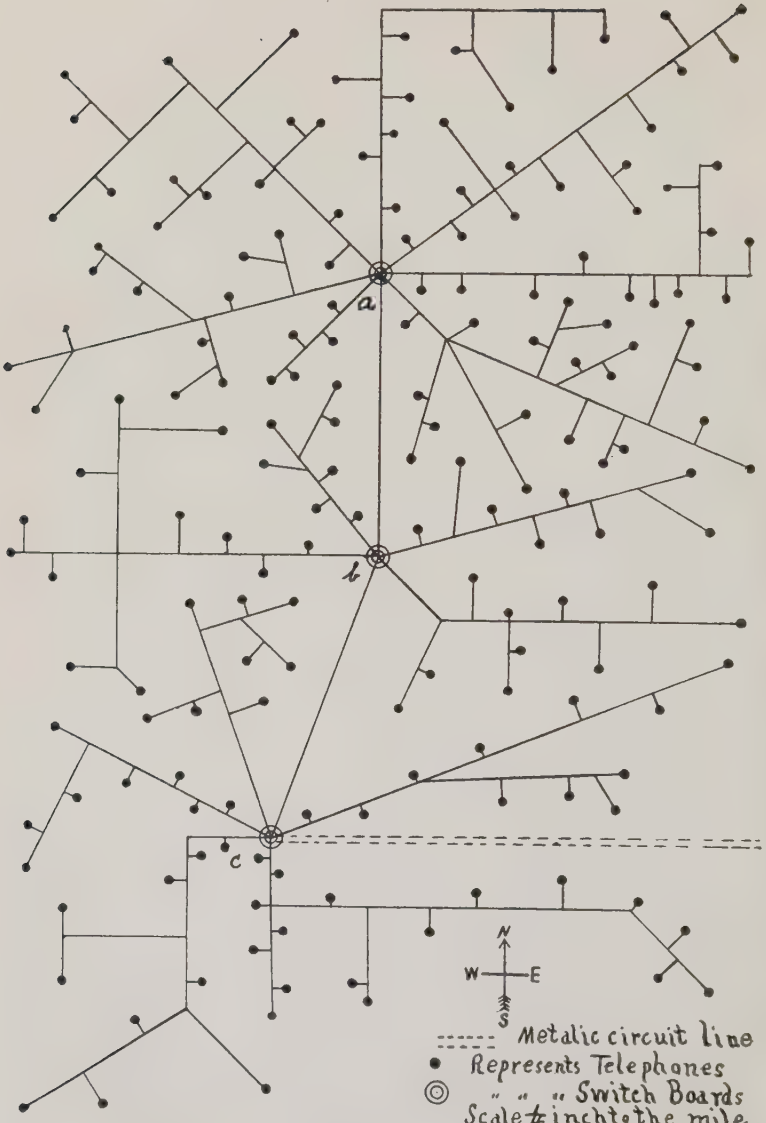
Series telephones	$10.00 each
S. B. drop, per subscriber	3.50
Poles, per subscriber, about	2.00
Line wire, cross arms and insulators, per subscriber, about	5.50
Labor on construction of system, per subscriber, about	14.00
Making a total of about, per subscriber	35.00

This cost is based upon using common return instead of grounded or metallic circuit. The common return system, if properly installed, will render very good service and will not be as expensive to maintain as a complete metallic circuit system. Where a complete metallic circuit system is used, that is, two individual wires for each subscriber, the wires have to be trans-

posed about every other pole and this system adds to the cost about five dollars per subscriber.

The above figures are based upon using No. 12 B. B. galvanized steel wire for line wire and No. 12 copper for common return. Should the entire system be wired up with copper wire, the average cost of common return system figured on the above basis is about $45.00 per subscriber and with copper complete metallic circuit about $55.00 per subscriber. In most climates, however, a No. 12 galvanized steel wire will be found to give excellent results and have a life of from 10 to 15 years.

It will be seen that the cost of installing a telephone system in a city is much greater per subscriber than in the country, and therefore higher rates for service must be charged, as the first investment is considerably heavier and more attention is required to keep the system in first class working order. More operating expenses are also required, as each individual subscriber has to have the exchange make every connection for him. The usual price charged per subscriber in towns of five thousand or less where every member has an individual line, is about $2.00 per month for a business telephone and $1.50 per month for a residence telephone. These prices hold good and are about the average for exchanges ranging between three and five hundred subscribers. With exchanges of more than one hundred members and less than three hundred, the average prices charged are $1.50 per month for business and $1.00 per month for residence telephone. The larger the number of subscribers, the greater the operating expenses, as there are more people to talk and, therefore, a greater use of every individual telephone, which necessitates a larger number of operators at the switchboard.


a
b
c
N
W
E
S
Metalic circuit line
Represents Telephones
" " " Switch Boards
Scale ¼ inch to the mile

PART II.

CHAPTER I.

TELEPHONE LINES AND PRINCIPLES OF CONNECTING THEM.

A telephone line is a metallic conductor connecting the telephones of a circuit. There are two fundamental principles used in connecting telephone lines. One of them is the series principle and the other is the multiple (ordinarily called) the bridging principle.

Fig. 2 shows the circuit of a series telephone line. Here, it will be noticed, the instruments are all connected in series, forming a series of telephones from which it derives its name.

The current that operates the ringing and the talking of the telephones on a series line has to pass through the ringer coils of each and every one of the telephones on the line.

Bridging or multiple telephone connections are shown in Fig. 3.

In this case each telephone is connected to both sides of the main telephone line or are bridged across the circuit, hence the system is termed a bridging telephone line. The difference between the series principle and the bridging principle will be readily understood by referring to Fig. 4 and Fig. 5.

Fig. 4 represents a water tank with a pipe leading down from it, having three wheels with their casings forming a part of the pipe. Paddles on each wheel extend down into the pipe so that no water can pass through and out of the pipe without moving all the wheels. The same amount of water that moves one wheel, passes on and moves the other wheels, thus illustrating that the series of wheels are operated by the same volume of water and also showing that each wheel requires and absorbs a certain amount of the pressure exerted by the water to drive the wheels.

Any instruments, such as telephones or other electric appliances, connected in series operate very much on this principle.

Bridging Metallic Circuit.

Series Metallic Circuit.

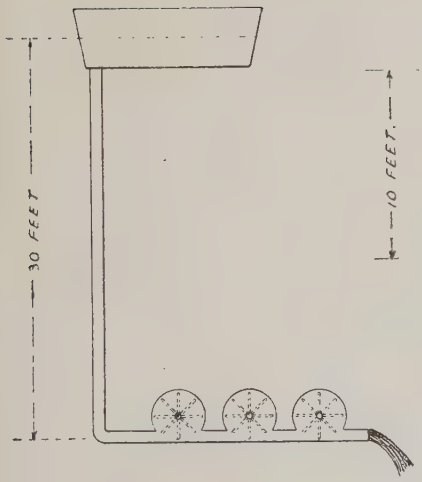


Figure 4.

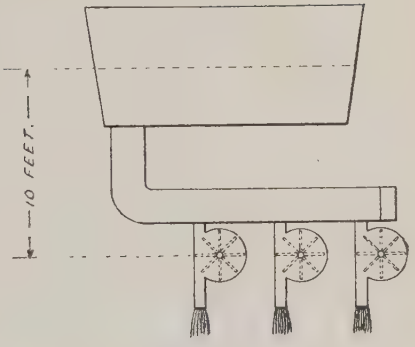


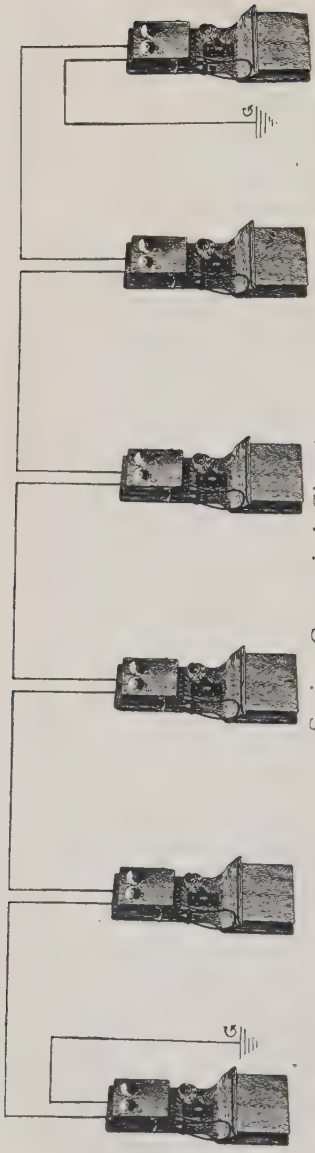
Figure 5.

The illustration shows 30 ft. height of water, which would give ten feet of water pressure to each of the three wheels.

Fig. 5 shows a water tank with three wheels arranged in separate pipes, being the same kind of wheels as shown in Fig. 4, but in this arrangement instead of the same volume of water passing through each one of the wheels, the volume of water divides, a proportionate amount passing through each wheel and the pressure of water remains the same for all three wheels. This system is somewhat on the principle of bridging telephones.

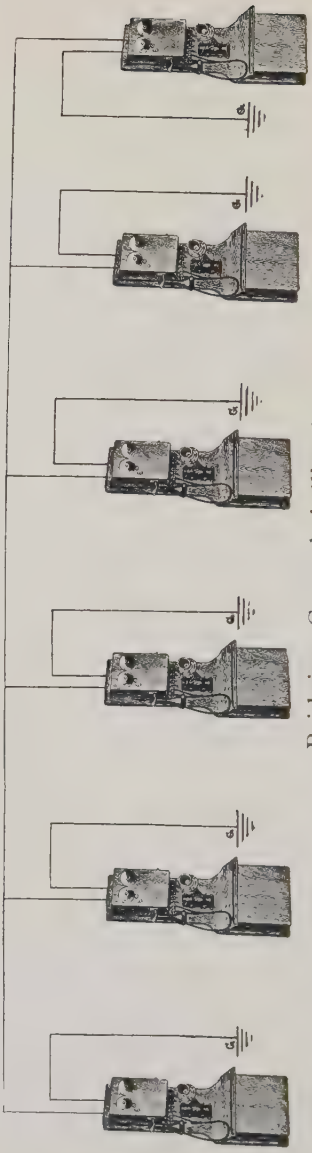
The generators of series telephones are wound to deliver a high pressure, with small volume. The generators of bridging telephones are wound to produce greater volume with less pressure.

The reader will note the similarity between the two systems of series and multiple distributions of water as shown in Fig. 4 and Fig. 5 to the series and bridging principle of distribution of electricity as shown in Fig. 2 and Fig. 3. Either the series or the bridging telephone system may use the ground for a return circuit and when so arranged it is called a ground return circuit.



Series Grounded Circuit.

Figure 6.



Bridging Grounded Circuit.

Figure 7.

Fig. 6 shows the series system with ground return.

Fig. 7 shows the bridging system with ground return.

The greater number of rural telephone lines use the bridging system with ground return, because with the bridging system you do not talk through the ringer coils, but ring and talk through the solid and unbroken line wire. When a number of telephones are used on one line, bridging telephones are far superior to series telephones. In actual practice, there is no one at the present time using series systems except where but two or three telephones go on one line, such as for local work or private lines.

When two wires, an out-going and a return wire, are used, the ground forming no part of the circuit, the line is then called a metallic circuit line.

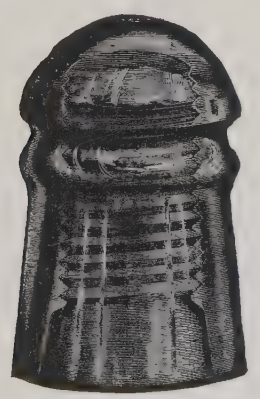


Figure 8.

Fig. 8 shows a regular glass insulator, such as is used for supporting telephone wires on brackets or cross arms.

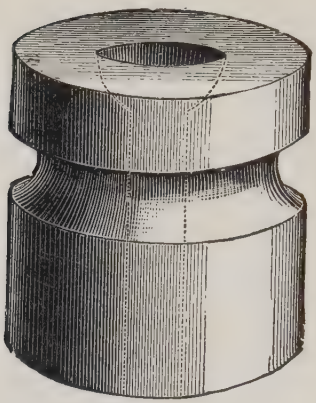


Figure 9.

Fig. 9 shows a No. 4 porcelain insulator (usually called porcelain knob.) These knobs make a convenient way of attaching the branch wire that runs from the main line to the house containing the telephone.

INSULATION.

Telephone lines of any kind must not be allowed to touch or come in contact with treetops, shrubbery or woodwork of any kind, as the telephone current would then leak from the line through the shrubbery or wood touching it and thus rob the telephones on the line of the ringing and talking current necessary to properly operate them.

Too much stress cannot be placed on this point of insulation. If the line runs through a wooded section of the country, the branches of trees that are near or touch the line should be trimmed off.

CHAPTER II.

PROPERTIES OF TELEPHONE LINES.

The four principal properties of telephone lines are as follows:

first, the insulation of the line;
second, the resistance of the line;
third, the capacity of the line;
fourth, the inductance of the line.

The word capacity as herein used does not mean the number of telephones the line will accommodate, but its electrical capacity, the meaning of which will be explained later on.

THE INSULATION of a telephone line means its isolation from any and everything else that would tend to conduct electricity away from the line. The insulation of a telephone line should be just as good as is possible to make it.

THE RESISTANCE of a telephone line is its resistance to the passage of an electric current. It may be likened to the friction of a water pipe offering resistance to the passage of water through the pipe, although electrical resistance and mechanical friction should not be confounded with each other. Different materials have different resistances, but for the same material the resistance of any wire is inversely proportional to the square of its diameter and directly proportional to its length. The resistance of a telephone line is, of course, a detriment to it and should not be any higher than practical limitations, such as the cost of the wire and the material used for the line wire will permit. The smaller the size of wire, the greater its resistance, but the less its cost per mile and conversely, the larger the size of wire, the less its resistance but the greater its cost per mile.

CAPACITY.

The capacity of a telephone line depends upon its size and also upon how close the line wire is to the ground, if ground return is used, or how close it is to the return wire, if metallic cir-

cuit return is used. In other words, the larger the wire in size and the nearer to its return circuit, whether ground or metallic, the greater the capacity of the circuit. Conversely, the smaller the line wire in size and the further apart the two conductors of the circuit, the less the capacity. Capacity in a telephone line is a disadvantage to it and should as far as possible be overcome.

To obtain a clearer conception of the effect of capacity on electric telephone currents, consider capacity as a leak between the two sides of a circuit, which is, of course, greater as the two sides are closer together and also greater in proportion to the surface area of the two wires or sides of the circuit. But consider that this is a peculiar kind of leak, inasmuch as it allows certain parts of the telephone current to leak from one side of the circuit to the other in a greater ratio than other parts of the telephone current. The heavier impulses of the voice will, of course, have higher voltage and will charge the line to a greater extent and will, therefore, leak from one side of the circuit to the other to a greater proportionate extent than would the current represented by the more modulated tones of the voice. Now, this will have the effect of changing the sound, flattening it as it were. Of course, in speaking of leakage in this way, it is only used as an illustration. What really happens is a transfer of current from one side of the circuit to the other by electrostatic induction; that is, if there is a positive charge given to one side of the circuit, it will induce a corresponding negative charge on the other side of the circuit and vice versa. An insulation leak will allow all currents of any character to leak from one side of the circuit to the other without in any way altering the characteristics of the different impulses of the current. On a telephone line of long length that is so constructed as to have great capacity, all of the current would be transferred from one side of the circuit to the other by electrostatic induction before it would reach the distant telephone. It is in this way that electrostatic induction acts to limit extraordinarily long distance talking.

A telephone line is very similar to a condenser, that is, it transfers a certain amount of every charge of electricity given to it from one side of the circuit to the other.

If a continuous direct current be applied to the line, the effect of capacity will only show itself when charging and discharging the line, and only at the first instant of the application or

withdrawal of electrical potential to or from the line. So long as the current continues constant in direction and constant in volume, the capacity of the circuit would not have any effect. It is alternating and vibratory current, those that vary in amount and direction, that are most effected by the property of capacity in lines.

INDUCTANCE.

Inductance of a telephone line, which is its fourth property, in a measure acts so as to offset or overcome the evil effects of capacity. Inductance is a kind of inertia, which requires a certain amount of time to overcome. It tends to retard the starting or stopping of an electric current in the circuit. It holds back the modulated and more rapid vibrations of the voice more in proportion than it does the louder and lower pitched tones, which, of course, has the tendency to disarrange these different tones of the voice with relation to each other. It will now be noticed that while capacity holds back one extreme of the vibrations, inductance retards the other extreme of the vibrations of the current. If capacity and inductance could be so balanced in a circuit that all of the different pitches or speeds of vibration of the voice current would be retarded to the same extent, then inductance and capacity would neutralize each other and would have no injurious effects on telephone currents. This, however, it is practically impossible to do and in actual practice a mean has to be struck between these factors that best suits all around practical conditions. The effect of too much self-inductance in a circuit is to make the transmitted speech sound muffled and indistinct, somewhat on the same order as the effect of electrostatic capacity.

Inductance between two or more lines is illustrated in the following manner: When a current of electricity is passing through a wire, a field of magnetic force is established around the wire in the form of concentric circles, which might be compared to the waves produced by dropping a pebble into still water. This wave system extends throughout the entire length of the circuit; and as the talking, as well as the ringing current is constantly changing in direction and strength, the waves of magnetic lines of force surrounding the conductor are constantly enlarging and vanishing. Imagine a series of pebbles being dropped into a pond of still water, one after the other, they

would produce a series of waves emanating outward from the pebbles in concentric circles. Now, if a cork or chip be floated on the water, within the zone of the waves thus produced, it would be tossed about by the waves and produce through its own inertia a wave system of its own. The same is the case with a telephone circuit. If another circuit be placed within the field of magnetic waves, a current of electricity will be induced in the wires of the circuit so placed, having all of the characteristics of the original current in the inducing circuit. This is the principal cause of "cross-talk" between telephone lines; that is, where two circuits run parallel with each other for a long distance and are not transposed with relation to each other, what is being said through the telephones on one line can be heard on the telephones of the other line, although there is no metallic connection between the two circuits.

The inductance of a telephone circuit is increased by having the two wires of the circuit further apart and is decreased by having the two wires of a circuit nearer together. Inductance in any circuit is directly proportional to the area enclosed by the two sides of the circuit, thus a circuit ten miles long with the two sides of the circuit five feet apart would have the same inductance as a circuit five miles long with the two sides of the circuit 10 feet apart or of a line 20 miles long with the two sides of the circuit 2½ feet apart, and so on.

The reader will now see that of the four properties in telephone lines, just given, there are two properties, namley: resistance and capacity, which in a measure work against each other; for example, by increasing the resistance, the capacity is decreased; and by increasing the capacity by means of larger wire, the resistance is decreased, making it possible to strike an average between both of these factors, which brings it about right for practical work.

No. 12 (Brown & Sharpe's gauge) hard drawn copper wire has been found in actual practice to give the best results for long distance talking; for while its resistance is considerably higher than would be the resistance of larger wire having a greater capacity, it has been found that the telephone instrument more readily overcomes the evil effects of resistance than it does of capacity.

The effect that resistance has on a telephone current is

merely to make the talking more faint. It does not in any way effect its clearness and distinctness. The effect that capacity has is to absorb the current and also, to a certain extent, change its characteristics, which makes the transmitted voice lack its natural tone as well as being greatly reduced in volume.

INDUCTANCE VS. CAPACITY.

Where inductance would tend to hold back the speed of the transmitted voice or ringer currents, capacity has the tendency of making them go faster than they naturally would, so that in a measure these two forces or factors, capacity and inductance, tend towards offsetting each other. If it were possible to construct a telephone line that would have the same effective amount of capacity as inductance, these two factors would entirely nullify each other. There would be nothing left to prevent talking enormous distances were it not for the resistance of the line, which, of course, could be overcome to any extent that the builders of the line might wish, by using large enough line wire. It is, however, practically impossible to balance or nullify the two factors of capacity and inductance by each other, as the capacity of a line, no matter how built, is far greater than is the inductance.

The first long distance line ever built, for talking between New York and Chicago, used No. 8 copper wire, and while it served fairly well, it did not give as good results as later lines that were built of No. 12 copper wire, or wire that had greater resistance but less capacity. This illustrates the point above mentioned about resistance not being much of a detriment, provided the capacity of the line could be overcome. If a line wire were used small enough to have but little capacity, its strength would be insufficient. In actual practice lines have to be built of heavy enough wire to endure the weather. No. 12 galvanized iron or steel wire is the size ordinarily used for constructing rural telephone lines; for, if good telephones are used with this wire, its resistance (which is only 32 Ohms per mile for iron and 40 Ohms for steel) is not appreciable for the short distances used. Its cost is much less than copper, and as in most climates its life is from 15 to 20 years, the author recommends as a practical proposition the use of iron or steel wire. The saving

in cost over copper is always important, except in some districts where there is a great deal of sulphur smoke from soft coal, then iron wire would only last a year or two, whereas copper wire would be practically indestructible by atmospheric conditions.

CHAPTER III.

TELEPHONE LINE CONSTRUCTION.

Poles commonly used for rural work are from 20 to 25 feet in length and are set from 4 to 4½ feet in the ground. Poles should be of cedar if possible, although other woods will serve the purpose very well. The poles should be straight and of about four inches in diameter at the top and larger where a great many lines are to be supported by them. The top should be pointed so as to form a sort of roof which will shed the rain. Where the pole is exposed above the ground the bark should be shaved off. Where but one or two wires are strung on the poles, brackets as shown in Fig. 10 may be used for supporting the wires.

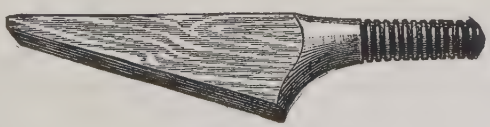


Figure 10.

BRACKETS.

Brackets are usually of oak and have a thread on the upper end upon which is screwed the glass insulator shown in Fig. 8. They are fastened to the sides of the poles by means of heavy screws or nails and are usually given two coats of red paint to preserve them.

CROSS ARMS.

Where several wires are to be strung on one set of poles, the poles are provided with cross arms, as shown in Fig. 11.

Figure 11.

This figure shows a standard form of cross arm. This form is $3\frac{1}{4}$x$4\frac{1}{2}$ inches and the length varies according to the number of wires to be strung on it. The limit for a cross arm is ten wires. The arms are painted with two coats of red. Holes are bored for $1\frac{1}{2}$ inch pins, made of locust, chestnut or oak. The pins are also painted with two coats of red. These pins are shown in Fig. 12.

Figure 12.

PINS.

Pins are forced into the holes in the cross arms and are provided with the glass insulators shown in Fig. 8.

The cross arms are mortised into the poles and in addition thereto are fastened to the poles with two lag screws.

Below is given a table showing the lengths of cross arms and the spacing of the pins for different numbers of wires on the cross arms.

CROSS ARM TABLE.

Length over all.	No. of pins.	Distance of pins from end.	Spacing between pins next to pole.	Spacing between pins on sides.
3 feet	2 pins	4 inches	28 inches	
4 feet	4 pins	4 inches	16 inches	12 inches
5 feet	4 pins	4 inches	18 inches	17 inches
6 feet	4 pins	4 inches	22 inches	21 inches
6 feet	6 pins	4 inches	16 inches	12 inches
8 feet	6 pins	4 inches	18 inches	16 inches
8 feet	8 pins	4 inches	16 inches	12 inches
10 feet	8 pins	4 inches	$17\frac{1}{2}$ inches	$11\frac{3}{4}$ inches
10 feet	10 pins	4 inches	16 inches	12 inches

Where considerable strain comes on the cross arms, they are also supported by wrought iron straps or brackets.

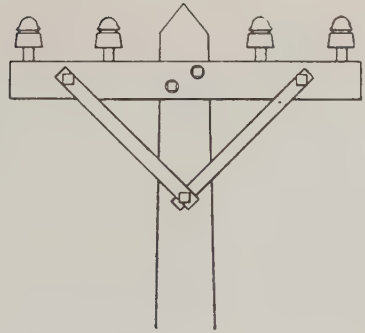


Figure 13.

Figure 13 shows a pole with cross arm and glass insulators mounted on pins as described above.

Where the line is built over an uneven and hilly section of the country, the longest poles should be used in the low places and the shortest poles in the high places, so as to make the line

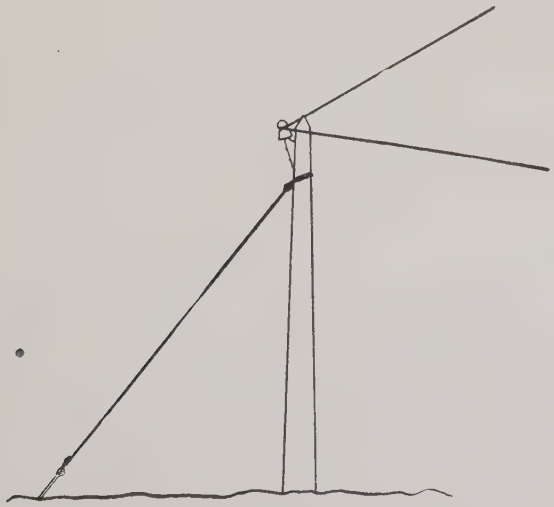


Figure 14.

as level as possible, as well as more sightly and of better construction. Poles should be set as nearly as possible in a straight line and perpendicularly. Wherever the line has to make a bend or angle, changing its direction, the pole or poles at the angle should be guyed or anchored, as shown in Figure 14 so that the strain on the pole may be uniform and not tend to pull it out of its position or bend it. The guy wire should not come too near the telephone wire, as it might touch it and ground the line, but at the same time it must be so placed as to take the strain directly back of the wire, or very nearly so.

THE GUY WIRE should consist of galvanized steel wire. There are several methods of fastening the guy wire to the ground. One way is to set a post deep into the ground, slanting away from the pole and fastening the guy wire around the post. Another method is to bury a log about ten inches in diameter and about four or five feet long, through which an iron rod has been passed and secured by a nut and washer as shown in Figure 15.

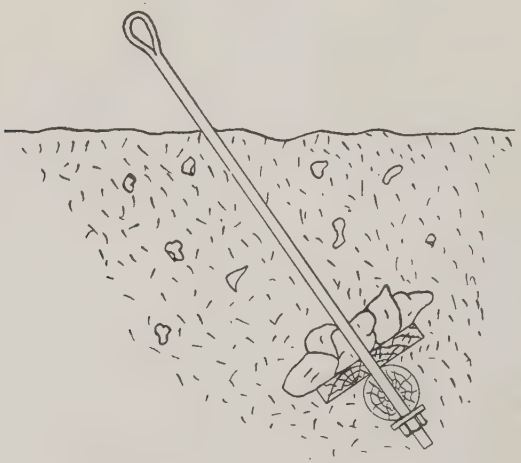


Figure 15.

The anchor rod should be about five-eighths of an inch in diameter and about four feet long and have an eye forged on the upper end for attaching the guy wire.

The guy wire should be passed at least twice around the pole and if it is likely to slip, should be fastened with heavy staples. Where the telephone line has a heavy curve in it, each of the poles in the bend should be guyed as described above. The quickest way to erect a line is to do all the work on the poles, such as attaching the brackets or cross arms before they are set into the holes. The poles are raised with pike poles much after the manner of raising the frame work of a barn.

When cross arms are used, they should face each other on every alternate pair of poles. If the soil is soft and marshy, two pieces of heavy planking about one foot by two feet should be nailed together at right angles and placed at the bottom of the hole and the hole filled with concrete, being thoroughly tamped as it is put in. A good concrete may be made as follows:

Portland or Natural cement.....1 part.
Sand .....2 parts.
Broken stone .....3 parts.

Where the soil is firm, however, the only point to observe is to thoroughly tamp the earth in the hole around the pole. After the poles are set in the holes and thoroughly tamped into position, a reel containing a coil of line wire is mounted so as to revolve freely, and placed upon a wagon. The wagon is then taken along the route of the line, reeling the wire off as it goes. All that is necessary is to place the wire on the cross arms or brackets and after a considerable length is so placed, about one quarter or half a mile, it may be drawn tight with block and tackle and tied to the insulators. A convenient form of block and tackle is shown in Figure 16.

Figure 16.

This may be purchased from any hardware store or supply dealer and is very commonly used.

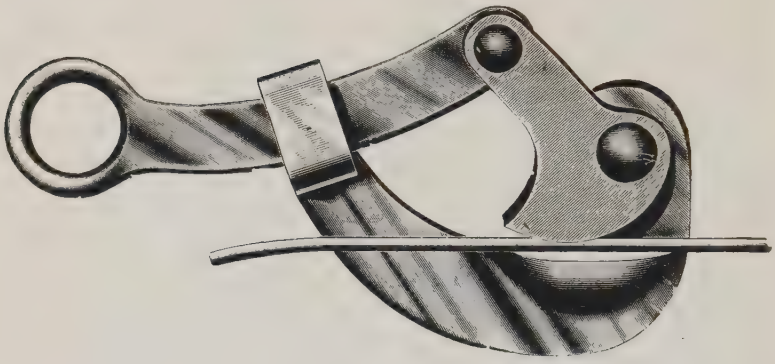


Figure 17.

Figure 17 shows wire clamp, which is fastened to the block and tackle by means of a wire or rope and has a cam arrangement whereby the wire is automatically gripped when a strain is exerted on the rope, but will immediately release the wire as soon as the strain on the rope ceases. The line is fastened to the insulators by means of tie wires.

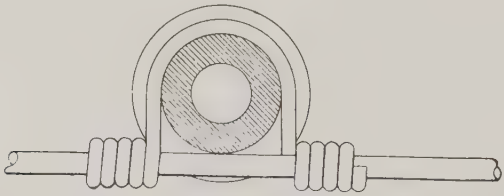


Figure 18.

Figure 18 shows the ordinary method of doing this. The tie wires are usually about 16 inches in length and should be, though not necessarily, of slightly smaller wire than the line wire. The tie is made by passing the line wire along the side of the insulator and holding it in the groove by the tie wire, which is twisted around it in opposite directions at each end. Care should be taken not to nick or injure the line wire when tying to the insulators. A very convenient form of pliers for cutting and fastening tie wires, making splices, etc., is shown in Figure 19.

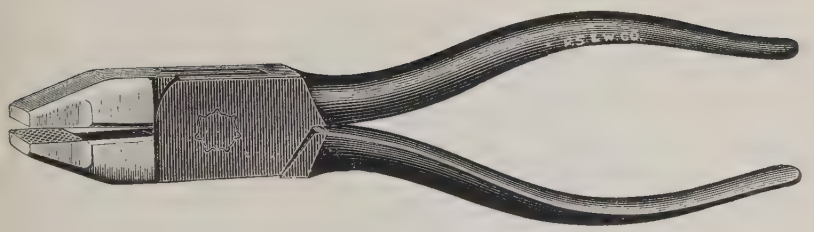


Figure 19.

All joints should be mechanically and electrically well made as shown in Figure 20 so that they may be strong and rigid and

Figure 20.

not shaken loose. A loose connection in a line is a very hard thing to locate and makes a very annoying source of trouble. Some people prefer to solder the joints. Where this is done, resin should be used as a flux and the joint should be dipped into a pot of molten solder and kept there until it is just as hot as the solder and until the solder adheres perfectly. Do not use any kind of acid as a flux, as this will cause the joint to rust and the wire will soon break at that point. In actual practice, if joints are well made mechanically, soldering is hardly necessary.

Where copper wire is used, special sleeves or connecters called "McIntire joints" are used. These joints consist of sleeves fastened side by side, as shown in Figure 21.

Figure 21.

The wire is passed through the sleeves so as to overlap, then the wire sleeve and all is simply twisted several times. This is a very good form of joint.

Figure 22.

Figure 22 shows the double sleeve after it is placed on a wire and twisted, making the complete joint. These sleeves are also made of galvanized iron for connecting iron line wires. A convenient tool for making joints is illustrated in Figue 23 and is called a splicing clamp.

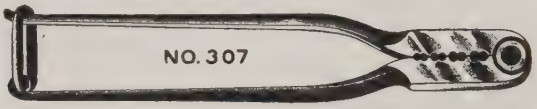


Figure 23.

It will be noticed that there are several sets of holes for different sizes of wire. By means of this tool the wires are held rigidly side by side while the splice is being made.

Hard drawn copper wire should not be soldered for the heat used in soldering would draw the hardness out of the wire and make it likely to stretch and break at that point. All wires should be drawn reasonably taut, so that the wind cannot blow them together where they sag between the poles. Telephone line wires are usually placed from twelve to twenty-eight inches apart when mounted on cross arms.

LINE LIGHTNING ARRESTERS should be placed on about every tenth pole. These line lightning arresters consist of galvanized iron wire of about No. 10 gauge, stapled to the pole before the pole is set into the ground so that the wire runs entirely to the bottom of the hole and it should be coiled around the pole at the bottom two or three times so as to make a good

earth connection. The top end of this wire should be bent into a loop or ring, encircling the line wire or wires, and should be rigidly fastened so that it cannot get against the line wires and ground them. As the lightning strikes the line and travels along, it reaches this ground or lightning rod, which has a tendency to peel the lightning, as it were, off the line wire and conduct it to the earth. In some localities, such as mountainous districts where lightning is unusually prevalent, it is best to put a lightning rod on every fifth pole. From 20 to 30 poles to the mile makes a very substantial line where there are not too many wires on the poles. Where there are a great many wires on the poles, they should be set closer together, averaging 35 to 40 poles to the mile.

Great care must be exercised to keep all the line wires from touching tree tops, shrubbery or wood of any kind, as the insulation of a telephone line must be kept as perfect as possible.

A useful article for line construction and repair work is the "climber." The climber is provided with straps, (as shown in

Figure 24.

Figure 24) to fasten it securely to the leg, having turned the spur to the inside. When climbing a pole, lean back as far as possible and put the full weight upon the spurs which will force them firmly into the pole.

In rural work where the poles are short, a light ladder may be used instead of the climbers and will be found more convenient for a person not expert in climbing.

Where a short line is constructed, a great many of the line tools here described for line construction may be dispensed with, provided ingenuity and care are used in bringing about the results.

Where ground return is used, care should be taken to get good ground connections. The earth itself makes a very good return path for telephone currents provided that good ground connections are obtained. The usual procedure in making a ground connection is to take a sharp iron rod and drive it four or five feet into the ground in some moist place where water is usually thrown around or near it. Then attach the ground wire that leads to the lightning arrester or telephone to this ground rod by means of scraping the rod bright and wrapping a copper wire around it several times, making a good metallic joint and soldering it in addition.

Ground rods made for the purpose can be obtained from telephone supply dealers. These ground rods are pointed at one end and at the top end have a bolt or screw for making connection with the telephone wire. Ordinary wood ashes thrown around or near the ground rod forms a very good means of keeping the ground connection moist. When water is thrown upon these ashes, it leaches the lye out of them. This lye being absorbed by the earth, gives the soil great capacity for absorbing and holding moisture, and will tend to keep the ground connection moist. This lye does not attack the iron rod and therefore will not rust it, nor is the earth as easily frozen as that in which there is no lye.

CHAPTER IV.

TRANSPOSING LINES AND COMMON RETURN.

Where telephone lines are parallel to trolley wires, electric light circuits or telegraph lines, it is almost impossible to get good results from a ground return circuit. With ground return circuit the inductance is so heavy that the telephone line picks up all of the vibration in the current and makes noises that interfere with conversation. Although for rural districts where no such disturbances exist, a ground return circuit is very satisfactory, especially when but one line runs on the same set of poles. Where several lines, with ground return circuit, are run on one set of poles for any considerable distance, such as a mile or two, there is sure to be what is called "cross talk" between the different circuits. That is: when one telephone line is in use, the subscribers on all of the other lines on that set of poles can hear

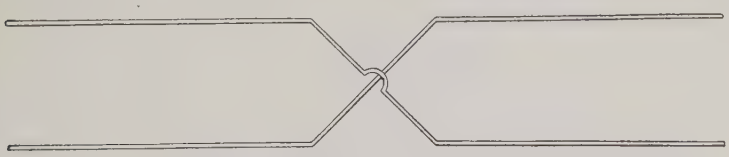


Figure 25.

what is being said; and if the lines run on the same set of poles for three or four miles, cross talk will be so strong as to be almost as plain as though there were a metallic connection between the lines. This cannot be avoided with ground return line, except by running but one line on one set of poles.

To entirely avoid cross talk, metallic circuits have to be used. That is: an out-going and a return wire for each telephone circuit; and where several circuits are on one set of poles, they have to be transposed with relation to each other, the wires of each circuit having to be crossed and re-crossed frequently as in Figure 25.

TRANSPOSITION OF LINES. The principle of transposing is to expose an equal length of both sides of a circuit at an equal distance from every other wire on the same set of poles. Where several circuits are to go on the same set of poles, the transpositions have to be figured out according to some regular order so as to accomplish the above mentioned object of exposing both sides of each pair of wires or circuit equally towards all other wires on the same set of poles. This transposing if properly done will absolutely avoid all cross talk between the different telephone circuits and also any outside interference from other electrical circuits.

Figure 26.

Figure 26 shows a transposition insulator, which is a double insulator so arranged that the wires can cross without coming in metallic contact with each other. The method of making transposition by means of this insulator is shown in Figure 27.

The order in which these transpositions should be made is shown in Figure 28.

In this figure is shown twenty metallic circuit telephone lines, forty wires in all. It will be noticed that the top cross arm transpositions are different from the second cross arm transpositions and so on. The transpositions on every cross arm are different, so as to accomplish the purpose of *exposing every wire equally to every other wire in every way*, which of course also exposes them equally in every way to any outside wires that should be running parallel to them.

COMMON RETURN. Where a great many lines are run on the same set of poles and for various reasons a ground return would not be satisfactory, a common return wire can be used. This common return wire takes the place of the ground return and should be two or three gauges heavier than the regular line wire that is used in connection with it. This common return wire can be placed near the center of the group of line wires on the poles. For instance, if five cross arms were to be used, this common return wire should be on the third cross arm and on a pin near the pole so as to occupy a position about cen-

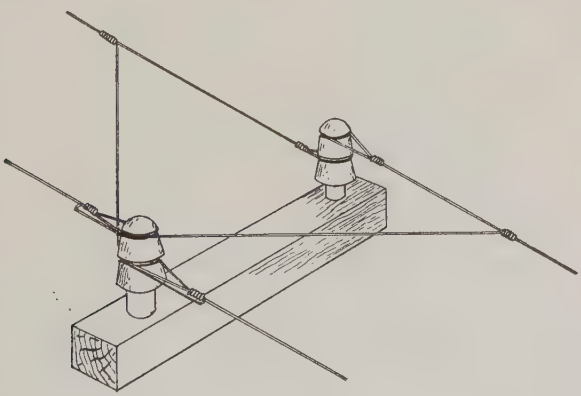


Figure 27.

tral within the group of wires. A common return wire does not have nearly the tendency to create "cross talk" between lines as does a ground return. Because the area, included by the circuit from a line wire to the common return wire, is not nearly so great as is the area included by the line wire and the ground. The smaller the area included by the outgoing and return wire of any circuit, the less the inductance is going to be. The difference between the area where the return circuit is placed close to the line and where the return circuit is on the ground, accounts for there being less cross talk when a common return wire is used instead of the ground.

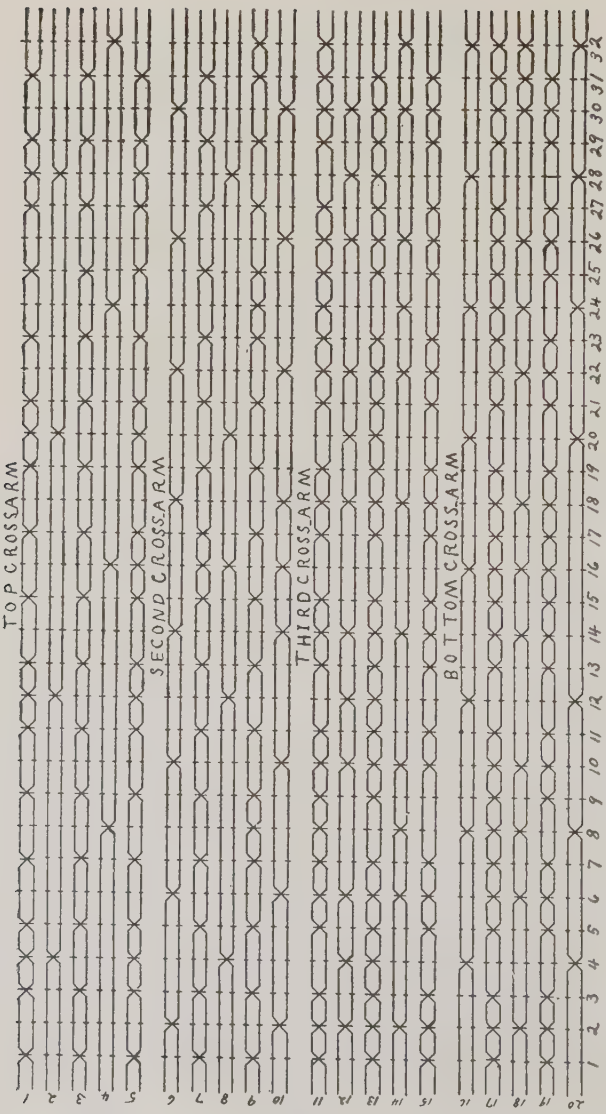

TOP CROSS ARM
SECOND CROSS ARM
THIRD CROSS ARM
BOTTOM CROSS ARM
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32

Figure 28.

Where trees are in the way of a telephone line, the wire may be guyed away from them by means of the split insulator shown in Figure 29.

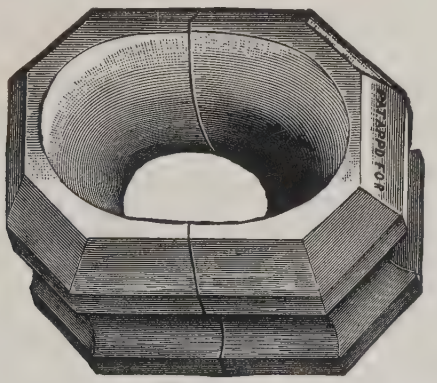


Figure 29.

The insulator is first placed around the wire and then the guy wire is fastened in the groove around the insulator, holding it together. The guy wire should be fastened in such a position that the line wire will not wear on the joints of the insulator. The line wire must not be fastened to the insulator, but should pass freely through it so that there will be no strain on the line

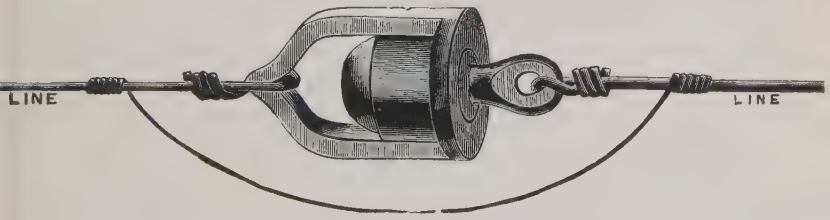


Figure 30.

wire when the insulator moves to and fro. Trees should not be used instead of poles, as they are likely to break the wires when swayed by the wind. The guy insulator may be fastened to them however, as the line wire is not fastened rigidly to the guy insulator.

To avoid the noise produced on a tight line by the wind, a device known as the "anti-hum" is used. Figure 30 shows this device.

Here the strain of the line comes upon a cushion of soft rubber, which effectively deadens all mechanical vibration, but as the rubber is an insulator, it is necessary to connect a wire around it, as shown in the cut, care of course being taken to obtain a good tight joint. Where a wire is connected around any device or piece of apparatus, the operation is called shunting it and the wire is called a shunt.

IN MAKING CONNECTION from the main line to a house or other location for a telephone, care should be taken to make a good joint on to the main line. The branch wire should be fastened to an insulator on the pole, so as not to let any side strain come upon the main line wire. Porcelain insulators make a very neat and convenient way of attaching the end of the branch wire to the houses or other location for the telephone.

CHAPTER V.

INSIDE HOUSE WIRING.

A rubber covered or weather proof copper wire (No. 16 B. & S. gauge) is usually run to the 'phone from where the branch wire from the main line terminates. The insulation should be carefully removed from this wire for two or three inches with a knife and the wire scraped bright and clean and then wrapped around the end of the branch wire and soldered. If not soldered, the joint can be bent into a semi-circle, which will have the tendency of making the copper wire grip the iron wire firmly and make a good connection. This copper wire should then run down to the lightning arrester or cut-out and should be fastened

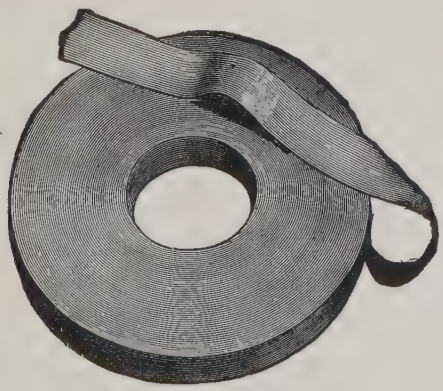


Figure 31.

to that part of it which leads to the fuse end of same; so that the current in passing into the telephone has first to go through the fuse, before it reaches the carbon lightning arrester.

In making splices with insulated wire, the insulation must first be removed from same by carefully whittling it off at the ends to be connected, care being taken not to nick the wire with the knife, as any slight nick in the wire will make it break at that

point when making the joint. After removing the insulation, polish the wire with sand paper or scrape it bright with the back of the knife blade. All electrical joints must be clean, so that clean metal is firmly connected to clean metal. This must be looked after in making any joint in wire intended for conducting electricity. The joint should then be made as shown in Fig. 20 and carefully soldered. If the splice is made with office wires, the joint after being soldered should be wrapped with two or three layers of insulating tape, which is shown in Fig. 31.

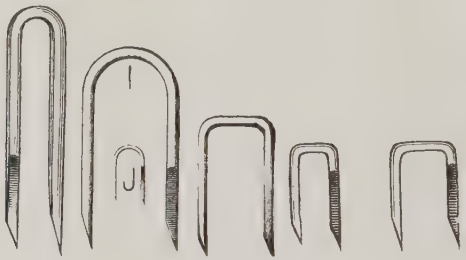


Figure 32.

The same care should be exercised when cleaning a wire to be connected to a binding post, as when cleaning it for a splice. Office wires are usually fastened to the woodwork by means of small staples, as shown in Fig. 32.

Two wires should never be fastened under the same staple, for the staple may cut through the insulation of each wire, thus short-circuiting them. A short circuit of this nature is very hard to locate, it often being necessary to remove all the staples before the fault is found. Two staples holding different wires should never be driven near each other, as they are likely to touch and form a short circuit. The proper way is to drive the staples at uniform distances apart, alternately holding one wire and then the other. When wires are connected to instruments, it is well to coil the end of the wire about a lead pencil, making a helix or coil, to have enough extra wire in case the end should become broken off while being connected.

Where a great many wires are to be run into a building,

such as to the switchboard in a telephone exchange, the lines are ended on a pole and are then connected to a lead covered cable by means of a cable head. The cable head is shown in Figure 33.

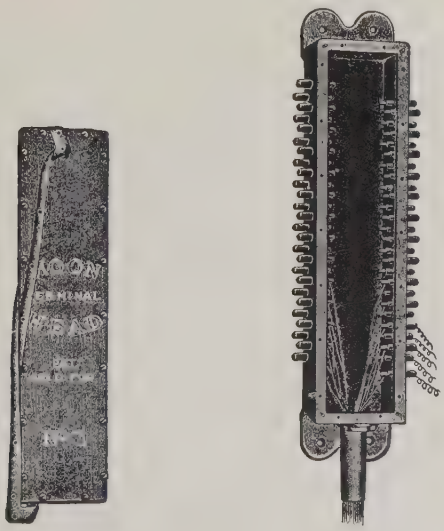


Figure 33.

The line wires are connected to the binding posts on the outside of the box, and the cable wires to the corresponding inside binding posts. The cover has a strip of soft rubber between it and the case, thus making the case water-proof. The cable head is mounted on the pole. Lead covered cable consists of wires insulted with paper and twisted together in pairs. The twist prevents cross talk between the different pairs. The twisted pairs of insulated wires are formed into a cable by winding cotton thread or paper around them and the cable is then covered with a lead sheath, hermetically sealing the cable.

A lead cable is a very delicate article and must be handled with extreme care and always kept as straight as possible so as not to kink it. A lead covered cable cannot even support its own weight and cannot have any strain placed upon it. The

cable is suspended from a steel wire by means of a cable clip. These clips should be placed every two or three feet apart, so that no appreciable strain shall come upon the cable. Another method of fastening the cable to the supporting steel cable or wire is to wrap them both together with cordage, but the first method is the best. Where the cable enters the building, it should run up into it, as otherwise the rain would run down it into the building; or a wire can be wrapped around the cable and hang down an inch or two to catch the rain and lead it off to the ground instead of into the building.

When using a cable in connection with ground return system, use metallic circuit cable. This cable has a twisted pair of wires for each telephone line and gives ground connection on the cable pole. One wire of each pair of wires being fastened to the ground connection at the cable pole, makes all the telephone lines metallic circuit while passing through the cable. Otherwise the wires are so close together in the cable, that unless they are twisted in pairs (each pair forming a metallic circuit) there would be a considerable amount of cross talk between the different telephone lines. Wherever a cable fastens onto overhead line wires, a lightning arrester for each pair of wires in the cable and a fuse wire should be placed between the cable and the line wires, to protect the wires in the cable from being struck by lightning. A very inexpensive cable terminal can be made out of a weatherproof wooden box, using rubber covered wires to run down from the different line wires, coming up into the cable box from the bottom, where they are attached to the fuse end of the lightning arrester. The wires in the cable should, of course, be attached to the opposite end of the lightning arrester.

CHAPTER VI.

USEFUL TABLES.

This chapter is devoted to different useful tables. Table No. 1 is the weight, resistance and breaking strain of Extra Best, Best galvanized iron telephone wire and Best Best iron telephone wire, and double galvanized steel wire in the different sizes from No. 0 to No. 18 Birmingham Wire Gauge. This is the wire gauge that is always used and referred to when speaking of galvanized iron or steel wire.

Table No. 1.

GALVANIZED IRON WIRE.

No. B. W. G.	Diameters in mils.	Weight, Pounds.		Breaking Weights Pounds.		Resistance per mile in Ohms.		
		1000 feet.	One Mile.	Iron	Steel	E. B. B.	B. B.	Steel.
0	340	304	1607	4821	9079	2.93	3.42	4.05
1	300	237	1251	3753	7068	3.76	4.4	5.2
2	284	212	1121	3363	6335	4.19	4.91	5.8
3	259	177	932	2796	5268	5.04	5.9	6.97
4	238	149	787	2361	4449	5.97	6.99	8.26
5	220	127	673	2019	3801	6.99	8.18	9.66
6	203	109	573	1719	3237	8.21	9.6	11.35
7	180	85	450	1350	2545	10.44	12.21	14.43
8	165	72	378	1134	2138	12.42	14.53	17.18
9	148	58	305	915	1720	15.44	18.06	21.35
10	134	47	250	750	1410	18.83	22.04	26.04
11	120	38	200	600	1131	23.48	27.48	32.47
12	109	31	165	495	933	28.46	33.3	39.36
13	95	24	125	375	709	37.47	43.85	51.82
14	83	18	96	288	541	49.08	57.44	67.88
15	72	13.7	72	216	407	65.23	76.33	90.21
16	65	11.1	59	177	332	80.03	93.66	110.7
17	58	8.9	47	141	264	100.5	120.4	139.
18	49	6.3	33	99	189	140.8	164.8	194.8

TESTS FOR GALVANIZED IRON OR STEEL WIRE.

(1) The wire ought to be soft and pliable and capable of elongating ten per cent without breaking after being galvanized. The wire if iron must not break under a less strain than two and one-half times its weight per mile, and if steel, not to break under less than five times its weight per mile.

(2) Tests for ductility may be made as follows: Let a piece of wire to be gripped by two vises six inches apart and twisted. The full number of twists must be distinctly visible between the vises on the six inch piece. The number of twists in a piece six inches in length for iron wire should not be less than 15 twists without breaking and for steel wire not less than ten twists without breaking.

(3) The galvanizing test is conducted as follows: two or three inches of the wire to be tested should be immersed in a saturated solution of sulphate of copper (ordinary blue vitriol, obtainable at any drug store) and permitted to remain in this solution one minute and then wiped clean with cloth. This is to be repeated four times, subjecting the wire to four immersions of one minute each in the solution, being wiped clean each time between dips. If the wire appears dark or black after four immersions, it shows that the zinc, which comprises the galvanizing, has *not* been all removed and that the galvanizing in consequence thereof is well done; but if the wire is of a copper color or the iron is exposed, it shows that the zinc is too thin. If a bright clean iron wire without any galvanizing were immersed in this solution, it would immediately become copper coated and on this principle the above test is produced. The solution eats off the zinc but does not show copper until it reaches the iron, when the solution will deposit metallic copper on the iron wire.

TABLE NUMBER TWO gives the diameter and circular area in one thousandths of an inch, weight per 1000 feet, weight per mile and breaking weight of copper wire.

B. & S. Gauge No.	Diam. in mils.	Circular mils (d2) 1 mil-.00 001 in.	Breaking Weight. Pounds.		Weight,		Resistance of pure Copper at 75° F.	
			Hard-drawn	An-nealed	Pounds per 1000 ft.	Pounds per mile.	Ohms per 1000 ft.	Ohms per mile.
0000	460.	211600.	8310	5650	641.	3382.	.04906	.25903
000	410.	168100.	6580	4480	509.	2687.	.06186	.32664
00	365.	133225.	5226	3553	403.	2129.	.07801	.41187
0	325.	105625.	4558	2818	320.	1688.	.09838	.51937
1	289.	83521.	3746	2234	253.	1335.	.12404	.65490
2	258.	66564.	3127	1772	202.	1064.	.15640	.82582
3	229.	52441.	2480	1405	159.	838.	.19723	1.0414
4	204.	41616.	1967	1114	126.	665.	.24869	1.3131
5	182.	33124.	1559	883	100.	529.	.31361	1.6558
6	162.	26244.	1237	700	79.	419.	.39546	2.0881
7	144.	20736.	980	555	63.	331.	.49871	2.6331
8	128.	16384.	778	440	50.	262.	.62881	3.3201
9	114.	12996.	617	349	39.	208.	.79281	4.1860
10	102.	10404.	489	277	32.	166.	1.	5.2800
11	91.	8281.	388	219	25.	132.	1.2607	6.6568
12	81.	6561.	307	174	20.	105.	1.5898	8.3940
13	72.	5184.	244	138	15.7	83.	2.0047	10.585
14	64.	4096.	193	109	12.4	65.	2.5278	13.347
15	57.	3249.	153	87	9.8	52.	3.1150	16.477
16	51.	2601.	133	69	7.9	42.	4.0191	21.221
17	45.	2025.	97	55	6.1	32.	5.0683	26.761
18	40.	1600.	77	43	4.8	25.6	6.3911	33.745
19	36.	1296.	61	34	3.9	20.7	8.0654	42.585
20	32.	1024.	48	27	3.1	16.4	10.163	53.658
21	28.5	812.3			2.5	13.	12.815	67.660
22	25.3	640.1			1.9	10.2	16.152	85.283
23	22.6	510.8			1.5	8.2	20.377	107.59
24	20.1	404.			1.2	6.5	25.695	135.67
25	17.9	320.4			.97	5.1	32.400	171.07
26	15.9	252.8			.77	4.	40.868	215.79
27	14.2	201.6			.61	3.2	51.519	272.02
28	12.6	158.8			.48	2.5	64.966	343.02
29	11.3	127.7			.39	2.	81.921	432.54
30	10.	100.			.3	1.6	103.30	545.39
31	8.9	79.2			.24	1.27	127.27	671.99
32	8.	64.			.19	1.02	164.26	867.27
33	7.1	50.4			.15	.81	207.08	1093.4
34	6.3	39.7			.12	.63	261.23	1379.3
35	5.6	31.4			.095	.5	329.35	1738.9
36	5.	25.			.076	.4	415.24	2192.5
37	4.4	19.8			.06	.32	523.76	2765.5
38	3.9	15.7			.05	.26	660.37	3486.7
39	3.5	12.4			.04	.21	832.48	4395.5
40	3.1	9.8			.03	.16	1049.7	5542.1

TESTS FOR HARD DRAWN COPPER LINE WIRE.

(1) The wire should be capable of being wrapped in six turns around wire of its own diameter in the same direction wrapped around wire of its own diameter in the same direction as the first wrapping without breaking and should also be capable of standing twists as follows:

Size No.	8	.....	30 twists.
" "	9	.....	35 "
" "	10	.....	40 "
" "	11	.....	42 "
" "	12	.....	44 "
" "	14	.....	47 "

The twists to be made as follows: the wire is gripped by two vises 12 inches apart, one of which is made to revolve at a speed of one revolution per second, the twists thus given to the wire will be recognized by means of an ink mark, which is drawn longitudinally along the wire before being twisted. During the twisting, this ink mark will form spirals on the wire. Thus the full number of twists in the wire between the vises will be visible.

The life of copper wire is practically infinite. In a short time after being put up it becomes coated with a thin film of oxide which protects the wire from any further atmospheric action.

Table No. 3.

WEATHERPROOF COPPER WIRE.

Numbers B. & S. Gauge.	Double Braid. Outside diam. in 32 ds inch.	Weight, Pounds.		Triple Braid. Outside diam. in 32 ds inch.	Weight, Pounds.	
		Per 1000 ft.	Per Mile.		Per 1000 ft.	Per Mile.
8	8	66	349	9	78	412
10	7	49	258	8	55	290
12	6	30	158	7	35	185
14	5	20	106	6	26	137
16	4	14	74	5	20	106
18	3	10	53	4	16	85

This table gives the outside diameters in thirty seconds of an inch, weight in pounds per 1000 feet and per mile for both the

double braid and triple braid weatherproof copper wire in sizes from No. 8 to No. 18 inclusive.

TABLE No. 4 gives the weight per mile of double braid and triple braid iron weatherproof wire from size No. 4 to No. 14 inclusive.

Table No. 4.

WEATHERPROOF IRON WIRE.

Numbers B. W. G	Weight per Mile. Pounds.	
	Double Braid.	Triple Braid.
4	997	1102
6	713	773
8	483	548
9	403	464
10	350	410
12	240	265
14	150	176

TABLE No. 5 gives area and diameter of bare wire and outside diameter and weight per 1000 feet of rubber covered copper wires from size No. 0 to No. 18 inclusive.

Table No. 5.

RUBBER COVERED WIRES.

Numbers B. & S. G.	Circular mils.	Diameters, Inches.		Weight per 1000 feet.
		Bare.	Outside.	
0	105.625	.325	.530	489
1	83.521	.289	.494	393
2	66.564	.258	.463	309
3	52.441	.229	.434	244
4	41.616	.204	.389	198
5	33.124	.182	.367	168
6	26.244	.162	.347	146
8	16.384	.128	.282	106
10	10.404	.102	.256	77
12	6.561	.081	.225	55
14	4.096	.064	.208	35
16	2.601	.051	.175	25
18	1.600	.040	.164	20

SPECIFICATIONS FOR TELEPHONE CABLES.

1. Conductors.

Each conductor shall be .36 inches in diameter (19 B. & S. G.) and have a conductivity of 98 per cent of that of pure soft copper.

2. Core.

Every conductor shall be insulated and twisted in pairs, the length of the twist not to exceed three inches, and formed into a core arranged in reverse layers.

3. Sheath.

The core shall be enclosed in a pipe composed of lead and tin, the amount of the tin shall not be less than two and nine-tenth per cent. The pipe shall be formed around the core, and shall be free from holes or other defects, and of uniform thickness and composition.

4. Electrostatic Capacity.

The average electrostatic capacity shall not exceed .080 of a microfarad per mile, each wire being measured against all the rest and sheath grounded; the electrostatic capacity of any wires so measured shall not exceed .085 of a microfarad per mile.

5. Insulation Resistance.

Each wire shall show an insulation of not less than 500 megohms per mile, at 60 degrees F., when laid, spliced and connected to terminal ready for use; each wire being measured against all the rest and sheath grounded.

6. Conductor Resistance.

Each conductor shall have a resistance of not more than 47 Ohms at 60 degress F., for each mile of cable, after the cable is laid and connected to the terminals.

Table No. 6.
TELEPHONE CABLES.

Number Pairs.	Outside Diameters. Inches.	Weights per 1000 feet. Pounds.	Number Pairs.	Outside Diameters. Inches.	Weights per 1000 feet. Pounds.
1	$\frac{5}{16}$	214	30	$1\frac{7}{16}$	2748
2	$\frac{3}{8}$	302	35	$1\frac{1}{2}$	2985
3	$\frac{1}{2}$	515	40	$1\frac{9}{16}$	3176
4	$\frac{9}{16}$	629	45	$1\frac{5}{8}$	3365
5	$\frac{5}{8}$	747	50	$1\frac{3}{4}$	3678
6	$\frac{21}{32}$	877	55	$1\frac{13}{16}$	3867
7	$\frac{11}{16}$	912	60	$1\frac{7}{8}$	4055
10	$\frac{13}{16}$	1214	65	$1\frac{15}{16}$	4241
12	$\frac{15}{16}$	1375	70	2	4430
15	1	1566	80	$2\frac{1}{8}$	4804
18	$1\frac{1}{16}$	1785	90	$2\frac{1}{4}$	5180
20	$1\frac{1}{8}$	1940	100	$2\frac{3}{8}$	5505
25	$1\frac{5}{16}$	2332			

OFFICE WIRES.

Office wire is usually made with a wind and a braid of cotton saturated with paraffine. It is sometimes required with a double braid or triple braid of cotton. The most common colors are red and white. Any combination of colors can be furnished.

Damp-proof office wire has the inside wind saturated with black weatherproof compound, while the outside finish is the same as ordinary office wire.

Annunciator wire has a covering consisting of two wraps in different directions of cotton saturated with paraffine. The outer covering is made in solid colors or a combination of two colors.

Double conductors for house wiring are of various kinds.

Two conductors twisted together, without any outside cover, form a convenient method of wiring for bells, telephones, etc. These conductors may be 18 B. & S., with double braid weatherproof or with annunciator insulation.

Two-conductor office wire may be two office wires laid side by side and covered with a two-color office braid, or it may consist of two annunciator wires so insulated.

Weatherproof cables consist of No. 18 B. & S. gauge annunciator wires, twisted into a cable and covered with rubber

tape and a braid of cotton saturated with weatherproof insulation. They weigh about ten pounds per 1,000 feet per conductor. For work inside a building, in dry places, the rubber tape may be omitted and the finishing braid made any color to correspond with the woodwork.

Table No. 7.

WEIGHT OF OFFICE AND ANNUNCIATOR WIRE.

Numbers B. & S. G.	Weight per 1000 ft.	
	Office Wire.	Annunciator Wire.
14	17	15
16	12	10
18	9	7
20	7	4½

Table No. 8

gives the average depth that telephone poles of different lengths are set in the ground.

25 foot pole is set 4½ feet in the ground.
30 foot pole is set 5 feet in the ground.
35 foot pole is set 5½ feet in the ground.
40 foot pole is set 5½ feet in the ground.
50 foot pole is set 6 feet in the ground.
60 foot pole is set 6½ feet in the ground.
70 foot pole is set 7 feet in the ground.

Table No. 9.

WEIGHTS OF SUBSTANCES.

Names of substances.	Average weights per cubic foot lbs.
Asphaltum	87.
Brick, common hard	125.
Brickwork, pressed brick	140.
Brickwork, ordinary	112.
Coal, anthracite, solid, of Pennsylvania	93.
Coal, anthracite, broken, loose	54.
Coal, bituminous, solid	84.
Coal, bituminous, broken, loose	49.
Coke, loose of good coal	62.
Cork	12.4
Earth, common, loam, dry, loose	76.

Names of substances.	Average Weights per cubic foot lbs.
Earth, common, loam, dry, moderately rammed	95.
Earth, as a soft, flowing mud	108.
Gneiss, common	168.
Granite	170.
Glass, crown	168.5
Glass, flint	218.3
Ice at O degree C.	57.2
Lime, thoroughly shaken	75.
Masonry, of granite or limestone, well dressed	165.
Mortar, hardened	103.
Mud, dry, close	80 to 100
Quartz	165.4
Sulphur	131.
Wax	58.7
Wood, ebony	74.9
Wood, birch	43.7
Wood, oak	46.8
Wood, pine	31.2
Water at 32 degrees F.	62.418

Table No. 10.

THE COMPARISON OF THERMOMETERS,

FAHRENHEIT TO CENTIGRADE. (t degrees F.-32) x $\frac{5}{9}$ equals Degrees C.

Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.
50	10.	67	19.4	84	28.9
51	10.6	68	20.	85	29.4
52	11.1	69	20.6	86	30.
53	11.7	70	21.1	87	30.6
54	12.2	71	21.7	88	31.1
55	12.8	72	22.2	89	31.7
56	13.3	73	22.8	90	32.2
57	13.9	74	23.3	91	32.8
58	14.4	75	23.9	92	33.3
59	15.	76	24.4	93	33.9
60	15.6	77	25.	94	34.4
61	16.1	78	25.6	95	35.
62	16.7	79	26.1	96	35.6
63	17.2	80	26.7	97	36.1
64	17.8	81	27.2	98	36.7
65	18.3	82	27.8	99	37.2
66	18.9	83	28.3	100	37.8

Table No. 11.

DECIMAL EQUIVALENTS OF PARTS OF AN INCH.

16ths.	32ds.	64ths.	Mils.	16ths.	32ds.	64ths.	Mils.
		1	15.625			33	515.625
	1	2	31.25		17	34	531.25
		3	46.875			35	546.875
1	2	4	62.5	9	18	36	562.5
		5	78.125			37	578.125
	3	6	93.75		19	38	593.75
		7	109.375			39	609.375
2	4	8	125.	10	20	40	625.
		9	140.625			41	640.625
	5	10	156.25		21	42	656.25
		11	171.875			43	671.875
3	6	12	187.5	11	22	44	687.5
		13	203.125			45	703.125
	7	14	218.75		23	46	718.75
		15	234.375			47	734.375
4	8	16	250.	12	24	48	750.
		17	265.625			49	765.625
	9	18	281.25		25	50	781.25
		19	296.875			51	796.875
5	10	20	312.5	13	26	52	812.5
		21	328.125			53	828.125
	11	22	343.75		27	54	843.75
		23	359.375			55	859.375
6	12	24	375.	14	28	56	875.
		25	390.625			57	890.625
	13	26	406.25		29	58	906.25
		27	421.875			59	921.875
7	14	28	437.5	15	30	60	937.5
		29	453.125			61	953.125
	15	30	468.75		31	62	968.75
		31	484.375			63	984.375
8	16	32	500.	16	32	64	1000.

PART THREE.

CHAPTER I.

ELECTRICAL UNITS AND FIRST PRINCIPLES.

The three fundamental properties of an electric current are:
first, the electrical pressure or potential;
second, the resistance offered by the conductor to the electrical pressure; and
third, the resulting current of electricity forced through the conductor, containing the electrical resistance, by the electrical pressure.

The law which governs the relation between potential, resistance, and current strength, is known as Ohms law and is expressed as follows: The strength of the current is equal to the potential divided by the resistance.

The values of potential and resistance may also be found by transposing Ohms law to read as follows: the pressure or potential is equal to the current strength multiplied by the resistance; or the resistance is equal to the potential divided by the current.

The unit of electrical pressure or potential is the Volt.

The unit of electrical resistance is the Ohm.

The unit of current strength is the Ampere.

Ohms law may then be read as follows: Amperes equal Volts divided by Ohms: Volts equal Amperes multiplied by Ohms; Ohms equal Volts divided by Amperes.

The law controlling the flow of electricity is similar in many ways to the law controlling the flow of water.

Figure 34 illustrates the relation between pressure, resistance and the resulting current.

First. The height of the water denotes pressure or volts.

Second. The spigot or outlet represents the resistance in Ohms.

Third. The quantity of water passing through the spigot represents the current in amperes.

If the spigot or faucet is turned nearly off, which increases the resistance, the resulting current of water will be comparatively small; while if turned on full, thus decreasing the resistance, the resulting stream will be large, or, in other words, the current strength would be much greater.

The value of the Volt is approximately the potential produced by a single cell of gravity battery which will be described in the next chapter.

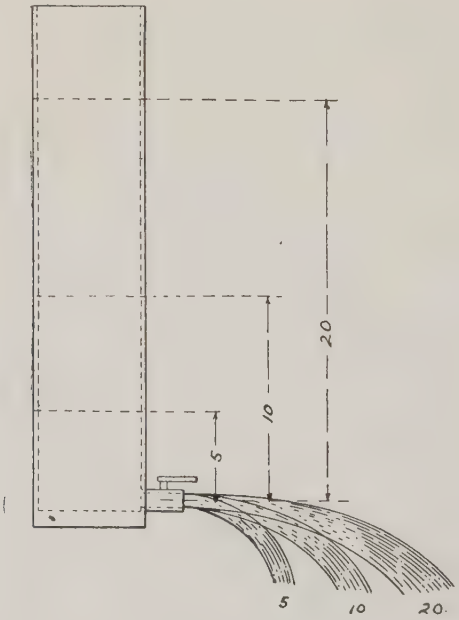


Figure 34.

The value of the Ohm is approximately the resistance offered by one foot of No. 40 B. & S. copper wire, which is .003145 inches in diameter, or about 132 feet of No. 12 steel telephone line wire.

The value of the Ampere is approximately the strength of current obtained by short-circuiting a cell of Leclanche wet battery.

The reason why the Leclanche cell is mentioned is because its voltage is approximately 1.5 Volts and the internal resistance of the cell is approximately 1.5 Ohms. Therefore, by Ohms law, the resulting current is equal to 1.5 Volts divided by 1.5 Ohms, equals one Ampere.

There is but one form of electricity, but when electricity is at rest, (as in a static or isolated condition) it is called Static Electricity. Thus, where there is a difference of potential between two conductors, not in contact with each other, there is static electricity. When electricity is in motion, it is called Dynamic Electricity. Thus, all electric currents are dynamic electricity.

There are three common methods of generating electricity. They may be classified thus: first, by electro magnetic or magneto electric devices of a mechanical nature, such as a dynamo or magneto generator; second, by chemical means, such as a battery; and, third, by friction.

The first method is used for electric lighting and power and for generating the current for signalling over telephone lines. The second method is used for producing small currents of low voltage, such as used for operating telephone transmitters. The third method is used principally for experimental and medical purposes; but is mentioned here because it generates static electricity of high potential, which, when discharged produces exactly the same effects as lightning, and the report is, in fact, miniature thunder. When the discharge takes place, the air is consumed; and the concussion, as the outer air rushes in, produces the report. There is absolutely no danger to persons from a telephone line, as the voltage used is comparatively low; and the currents so small that they are perfectly harmless; and the lightning arresters conduct what lightning comes over the line, to the ground.

When a current flows steadily in one direction only, it is called a direct current. All battery currents are direct currents.

When a current flows repeatedly, first in one direction and then in the other, it is called an alternating current. The current given out by all dynamos is alternating unless it is constantly switched or commuted so as to keep it in one direction. This operation is called commutation and a dynamo equipped with a commutator is called a direct current dynamo.

When a current of electricity flows through a circuit, it produces magnetic wave systems around the wires of the circuit. If another circuit be placed within the zone of the magnetic waves, and the waves be agitated by changing the strength or direction of the current in the first circuit, a current of electricity will be generated in the second circuit. Similar results would be obtained if the waves were not agitated; but the circuits moved further apart or nearer one another so as to change their relative positions. This effect is called induction. Thus a current is induced in the second circuit by means of the current in the first circuit. The method of inducing a current into the second circuit by varying the strength of the current in the first one is employed in the telephone induction coil. The method of inducing a current in the second circuit by constantly changing its position with respect to the circuit conveying the inducing current, is employed in the dynamo.

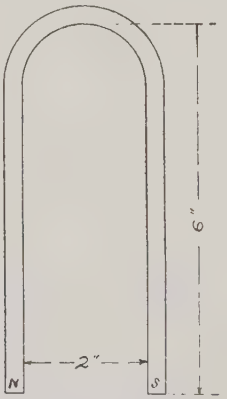


Figure 35.

MAGNETS. In making electro magnets, insulated wire is coiled around an iron core; because magnetic induction, called magnetic lines of force, is much stronger in iron than any other material. When thus arranged the whole is called an electro magnet. If a hardened steel core be used instead of soft iron, it will remain magnetized after the current ceases to flow around it. It is then called a permanent magnet. This form of magnet is bent

into the form of a horse shoe so as to bring its poles near together; and used on magneto generators for sending signalling current over telephone lines.

Figure 35 shows a horse shoe magnet. All magnets, no matter what their shape, have two poles of equal strength, one is called the north seeking pole and the other the south seeking pole. The reason for so calling them is that they have a tendency to point north and south if suspended and given free movement. This fact is taken advantage of in the ordinary compass needle.

The law of the magnet is this: like poles repel one another; and unlike poles attract one another. Thus a north seeking pole and a south seeking pole will attract each other, while two north seeking or two south seeking poles will repel each other.

The poles of a magnet are strongest at or very near the ends and gradually become weaker near the center of the magnet. The point at the center where there is no attraction at all is called the neutral point. The movable part which connects magnetically the two poles of a magnet whether on a horse shoe magnet or on a dynamo is called its armature. In a dynamo, the wire is wound longitudinally on the armature; and the armature revolves between the poles of the magnets, called the field magnet, or simply the field. This brings the coils of wire alternately before the south pole and then the north pole, thus producing an alternating current, as above stated.

The magneto generator as used for signalling on telephone lines is a simple form of dynamo with permanent magnets for its field magnets, and generates an alternating current. Wherever there is an alternating current, two new factors besides resistance play an important part. These factors are inductance and capacity and were mentioned in Part Two, as it was necessary to show their effect on telephone lines.

The unit of capacity is the Farad, but as this is too large a unit for practical purposes a new unit derived therefrom, (being but one millionth of a Farad) is called micro-Farad.

The unit of inductance is called the Henry and represents the inductance of a circuit when the voltage induced in this circuit is one Volt; while the inducing current varies at the rate of one ampere per second. Inductance is a decided disadvantage in a telephone line (as explained in Part Two), but it is the essential

principle applied in the telephone induction coil. Here a low voltage battery current may be employed in the primary or first circuit; and an alternating current of comparatively high voltage and of wide variation produced in the second circuit, by disturbing the magnetic field about the secondary, by means of varying the strength of the primary current, with the voice as applied to the microphone.

All induced currents are alternating currents. The current in the primary may be direct; but when it is interrupted or changed in strength the current induced in the secondary will always be alternating, as stated above. There will be no current in the secondary winding unless the strength of the current is changing in the primary. The strength of the current in the primary circuit is changed by the sound waves produced by the voice by means of a device known as the microphone or "transmitter head," which is connected in series with the primary coil and battery.

When the current is increasing in strength, in the primary circuit, it induces a current in one direction; and when it is decreasing in the primary circuit, it induces a current in the opposite direction in the secondary circuit; thus showing that the rise and fall in strength of the current, in the primary circuit, produces, instead of a rise and fall in the secondary, a complete reversal of the direction of current in the secondary circuit; thus making an alternating current in the secondary circuit.

THE MICROPHONE consists of fine particles of carbon placed between a diaphragm and a block or cup of carbon. The resistance of these carbon particles changes greatly under pressure or vibration; and the sound waves from the voice, striking the diaphragm changes the resistance of the loose carbon particles in the transmitter, and consequently the current in the induction coil, thus sending over the line electrical impulses exactly similar in character to the sound waves producing them.

The speed of electricity through a non-inductive circuit with no capacity is in round numbers about 288,000 miles per second. That means if a wire were stretched around the world at the equator 25 times, electricity would circulate around the earth at the equator 11 times in one second; so that no matter what distance apart two telephones may be, the talking from one to the other of them is practically instantaneous. Two people can talk

to each other who are 500 miles apart and there will be less time consumed in the voice of one reaching the ear of the other, than if they were but ten feet apart in the same room talking in the ordinary way.

Sound travels through the air at about the rate of one mile in six seconds. It will now be seen how much faster is the transmission of the human voice by electrical means than through the atmosphere in the ordinary way. Take a line with a telephone at each end of it and what takes place when two people are talking through them is this: in speaking into the transmitter you impress the characteristics of your voice upon the electric current that is passing through the transmitter. This electric current that has voice characteristics impressed upon it, of course passes through the primary coil of the induction coil, which in turn induces in the secondary coil of the induction coil a current exactly similar in characteristics only with a higher voltage or pressure and with the variations of the current magnified into alternations of the current. This current from the secondary coil, which, higher in voltage, is capable of overcoming the resistance of the line to a much greater extent than the primary current, travels instantaneously to the telephone at the other end of the line; and through the medium of the ear telephone or receiver is re-transmitted into atmospheric vibrations. These are, of course, perceptible to the ear and the result is that speech is transmitted. As both instruments are just alike and the process applying to both ends of the line the same, it will be seen that it is not the voice at all that travels, but the electric impulses.

CHAPTER II.

BATTERIES.

Electricity is produced by chemical means by inserting two pieces of metal into a liquid of some kind, either an alkali or an acid, that will attack and dissolve one of the metals and will not dissolve the other. The metal dissolved is always the negative pole of the battery.

There are two kinds of open circuit batteries usually employed for telephone work. What is meant by an open circuit battery is a cell of battery the circuit of which is to be left open

Figure 36.

normally; and the circuit of which is only closed for a short time, when in the act of using the battery, as in talking.

OPEN CIRCUIT BATTERIES in general have a higher voltage than closed circuit batteries; but polarize or become clog-

ged with hydrogen gas so as to prevent their output in current, if left too long at one time on a closed circuit. Open circuit batteries are usually employed in the battery box for furnishing current to the telephone transmitter. The usual types of open circuit batteries are the dry battery and the wet battery. Both of these batteries employ salamoniac as an exciting fluid with carbon and dioxide of manganese as the positive pole and zinc as the negative pole.

Of late years dry batteries have become very popular for telephone use, as they do not require any handling of solution; but when worn out, they cannot be recharged. The wet batteries can, of course, be recharged with salamoniac and a new zinc placed in it at the expense of about one-half the cost of a dry battery.

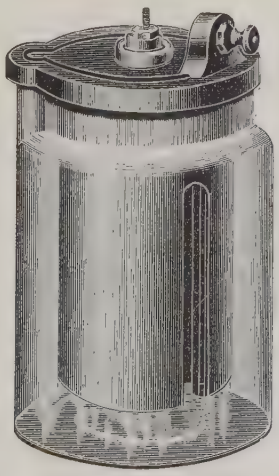


Figure 37.

Figure 36 shows cut of a dry battery of a very popular type. The voltage of this battery is about 1.5 volts with about 15 amperes on short circuit and, therefore, an internal resistance of about one-tenth of an Ohm. It polarizes very slowly, and when polarized, rapidly recuperates and regains in a short while its normal voltage.

All wet cells of battery employing carbon and zinc as the two electrodes, with the carbon surrounded by dioxide of manganese in some form or another, are called Leclanche batteries, owing to their being invented by a man of that name. Figure 37 shows a Leclanche wet cell of battery.

To properly set up Leclanche batteries, the salamoniac is dissolved in as pure water as is obtainable, rain or cistern water is very good. Entirely dissolve the salamoniac in pure cold water and pour this solution in the battery jar to such a height that when the zinc and carbon is immersed in the solution, the solution will rise to the shoulder of the jar. Never allow any undissolved salamoniac to remain in the bottom of the battery jar, as it will clog up the battery and might eventually internally short-circuit it. The battery is then ready for use. In recharging Leclanche cells of battery, pour out the old solution, thoroughly rinse out the jar and wash the carbon element by letting it soak in hot water for a few minutes. If the zinc has not all been consumed, it can be washed and scraped off clean and replaced, but if the zinc is too far gone, a new zinc should be used and the solution replaced according to directions for setting up the battery.

Figure 38.

CLOSED CIRCUIT BATTERIES are usually employed on switchboard transmitters or places where current is in use so much of the time as to render them practically on a closed circuit all of the time.

Figure 38 shows a cell of gravity battery. The exciting fluid and positive and negative electrodes of this battery are copper, in sulphate of copper solution, and zinc in sulphate of zinc solution. As these two liquids have different specific gravities, the copper sulphate solution being the heavier and staying at the bottom where the copper electrode is, these batteries are called gravity batteries from the principle of gravity being employed to keep the two solutions separate.

The voltage of this gravity Daniel cell is approximately one Volt, but its internal resistance is quite high, being about two Ohms, which would only allow this battery to give one Volt divided by two Ohms which equals one-half of an Ampere on short circuit. This battery, however, is very constant in its action, there being no variation in voltage and but slight variation in its internal resistance when left on a closed circuit for long periods of time or constantly till the elements are exhausted.

To set up a gravity Daniel cell, unfold the copper sheet so as to form a cross and place it in the bottom of the jar. Fill the jar with blue vitriol crystals to about level with the top of the copper electrode. Suspend the crow-foot zinc by means of its hook on the rim of the jar. Pour clean water into the jar so as to cover the zinc. Then pour into this water a quantity equivalent to about one-half of a teaspoonful of ordinary sulphuric acid (which can be obtained at any drug store). Short-circuiting the battery by connecting the copper and zinc together by means of a piece of wire and allow the battery to stand on short circuit for a few hours, when the copper sulphate will be partly dissolved and will form a blue solution, which will reach about half way up to the zinc. The zinc will be in an almost clear solution of sulphate of zinc. The crow-foot battery is then in first class condition, and ready for use.

If the crow-foot battery is worked too long without attention the zinc sulphate solution will keep increasing until it would finally reach the copper electrode, but before this point is reached, about two-thirds of the zinc sulphate solution should be drawn out of the battery with a syringe or siphon so as not to disturb the copper sulphate solution, and the amount drawn out replaced with clean water and more sulphate of copper crystals carefully dropped in, so as not to stir up the solution. This is to

keep the supply of copper sulphate crystals about level with the top of the copper electrode.

On the other hand, if the battery is not left long enough on closed circuit, or does not have work enough to do, the copper sulphate solution will gradually rise up until it reaches the zinc, in which case, it would deposit copper on the zinc and cause local action to start which would rapidly destroy the zinc. The remedy for this is to short-circuit the battery and give it work to do before this point is reached.

The main point to be remembered and looked after in maintaining gravity batteries of this type, is to keep that line which joins the two solutions about midway between the zinc and copper. When the battery is in this condition it is in its best working order.

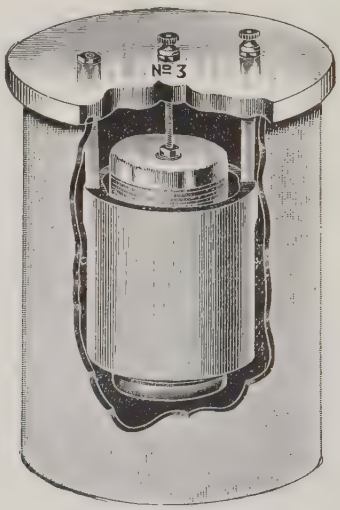


Figure 39.

Figure 39 shows another form of closed circuit battery in which zinc and copper with copper oxide as the depolarizing agent, form the metallic elements. Zinc, as usual, is the negative pole, and the copper element is the positive pole. The solution for this battery is a saturated solution of caustic potash. The

voltage of this battery is about three-fourths of a volt, but its internal resistance is very low, only about one-tenth of an Ohm, which, of course, allows the battery to give on short circuit a current of 7½ amperes. This is a very good form of battery for use on switchboards where the operator's transmitter is in use but part of the time. It can also be used, of course, when the operator's transmitter is always in use. It does not polarize and requires no attention whatever until the zinc is entirely consumed. The battery is so proportioned that the solution, the zinc, and the copper oxide are all consumed at about the same time.

This figure shows this battery with part of the glass jar and zinc element broken away so as to show the zinc element surrounding the copper element. This battery is manufactured by the Nungessor Electric Battery Co., of Cleveland, Ohio, and the size usually used for telephone work is either 4½x4½ square by 7½ high or else the 4½ round by 7½ high. The above description refers to batteries of this size.

The first cost of this battery is somewhat higher than the gravity Daniel cell, but, of course, it does not require the attention that a gravity cell does in order to keep it in first class working order.

Properly, to set up batteries of this type, the caustic potash comes in a tin can which is opened and dissolved in the proper amount of water, to come within about two inches of the top of the jar; then heavy paraffine oil, which comes in a vial with the solution, is poured over the solution to prevent its evaporation and creeping of the salts over the top edge of the jar; and then the zinc and copper elements, which are fastened to the cover of the jar, are immersed in the solution. The cell of battery is then ready for use and need not be disturbed again until entirely worn out and ready for a renewal of the elements.

RENEWAL OF CAUSTIC POTASH BATTERY. Place new copper dioxide in the copper wire gauze cup. Place a new zinc element surrounding the copper element. Put in new solution as in setting up the battery, which makes it as good as new. The copper gauze cup does not become consumed, but it is only the solution, the zinc and the copper oxide that are consumed in this battery by the production of electricity. In the 4½ by 7½ size, this battery has a capacity of 300 Ampere hours, that is, it

will deliver one Ampere of current for 300 hours, or three Amperes of current for 100 hours, or one-tenth of an Ampere for 3,000 hours, or any amount of current hours that by multiplying together make 300 Ampere hours.

In the selection of batteries, either open or closed circuit, there is a great deal of leeway allowable, as there are several different makes of batteries that do very good work. In mentioning the batteries referred to in this chapter, the author has tried to pick out the standard types of batteries that are in most general use and, therefore, to be assumed, give satisfaction.

CHAPTER III.

DIFFERENT METHODS OF CONNECTING BATTERIES FOR DIFFERENT RESULTS.

In this chapter is illustrated the four different methods of connecting batteries:

Figure 40.

Figure 40 shows the series connection where the carbon of one cell of battery connects to the zinc of another cell of battery, and so on through the entire series. This system of connecting batteries multiplies the Voltage of one cell by the number of cells connected in one series group. That is: if you are connecting four batteries of 1½ Volts each, you would have 1½ times four, which would be six Volts for the entire group of batteries; but you would not increase the current strength of the battery on short circuit, as you do not decrease the internal resistance, the internal resistance as the Voltage being also multiplied by the number of cells in series. This type of battery connection is employed wherever considerable resistance has to be overcome outside of the battery resistance.

Telephone batteries are usually two cells in number; sometimes three, and are always connected in series with each other, as in Figure 40. That is: the zinc of one cell of battery is connected to the carbon of the other cell of battery; which, therefore, leaves a zinc pole on one end of the battery and a carbon pole on the other end, to be connected to the two battery wires, which lead the current to the primary circuit of the telephone.

Figure 41 shows the method of connecting batteries in mulitple. In this connection, all of the carbon or positive elements are connected together; all of the zinc or negative elements are connected together; the carbon elements forming the positive

side of the circuit and the zinc elements the negative side. In this method of connecting batteries, you do not increase the voltage, but you do increase the current which the group will give on short circuit by decreasing the internal resistance of the group. Connecting batteries in multiple has the same effect as making them all into one large cell of battery, with as much zinc and carbon surface as is contained by all of the batteries in the group. In other words, if you wanted more Amperes without increasing the Volts you would connect your batteries in multiple, as in Figure 41. On the other hand, if you wanted more Volts, you would connect your batteries in series, as in Figure 40.

As in Figure 41, the internal resistance of the group of batteries would be one-fourth of the internal resistance of one cell, for to obtain the internal resistance of a group of cells in multiple, divide the resistance of one cell by the number of cells in

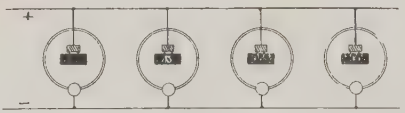


Figure 41.

the group. If the internal resistance of one cell is 1½ Ohms, and four cells are connected together in multiple, divide 1½ Ohms by four, which gives three eighths of an Ohm as the internal resistance of the entire group of batteries. To obtain the current this group would give on short circuit, divide 1½ Volts by three-eighths of an Ohm, (which is the internal resistance of the battery) and four Amperes is given as the quantity of current this group would deliver on short circuit.

Where more current and more Voltage both is wanted than can be obtained by the series or by the multiple principles of connections, combinations of these two principles are employed. One of these combinations is called the series multiple principle. (Figure 42.) The other is called the multiple series principle.

Figure 42 shows the series multiple connection, which means a series of groups of battery in which the cells in the individual groups are connected in multiple.

To figure out the internal resistance, voltage and current, that this group of eight cells would give on short circuit, you

would proceed as follows: as the internal resistance of each group is three-eights of an Ohm; and the two groups are connected in series, which multiplies three-eights of an Ohm by two; we find three-fourths of an Ohm as the internal resistance of the group. Now, inasmuch as the Voltage of each group is 1½ Volts,

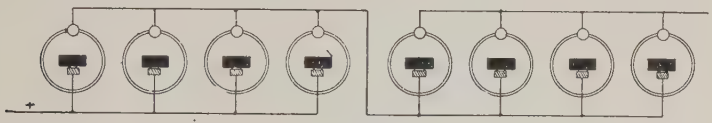


Figure 42.

and the two groups are connected in series, we would multiply 1½ Volts by two, which gives us three Volts for the group. Now, to obtain the current, we would divide three Volts by three-fourths of an Ohm, which gives us four Amperes as the exact amount of current that would be given us on short circuit. In grouping batteries this way, we do not increase the current that each group would give on short circuit, but we do increase the Voltage in direct proportion to the number of equal groups so connected. The result of connecting batteries this way is the same as joining in series a number of large cells of battery, since each individual multiple group represents a cell of battery.

With the multiple series method of connection as shown in Figure 43, (which really means a multiple, or many series con-

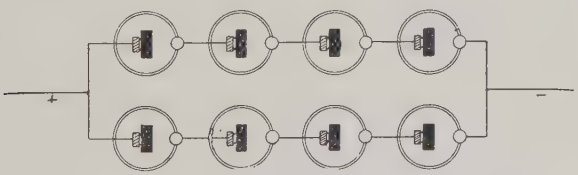


Figure 43.

nected groups, connected in multiple,) the current is increased by reducing the internal resistance of the group.

To figure out the internal resistance, Voltage and current of this group (Figure 43), we have 1½ Ohms internal resistance for each cell of battery multiplied by the four cells of each group, which gives us six Ohms as the internal resistance of each half

of the group. Now, inasmuch as these two groups are connected in multiple, we divide the internal resistance on one group by the number of groups, which in this case is two. This gives us three Ohms as the internal resistance of the entire group. Now, the Voltage of each group is six Volts and as the groups are connected in multiple, we do not increase the Voltage. We, therefore, have six Volts as the Voltage of the entire group. Now divide six Volts by three Ohms internal resistance, which gives us two Amperes as the output of the group on short circuit. Of course, any desired number of groups may be connected in multiple; the groups so added would not change the voltage but would add to the current by decreasing the internal resistance of the entire group. To obtain the resistance of the entire group of batteries so connected, divide the internal resistance of one group by the number of groups. Whereas, in the series multiple connection (Figure 42) to obtain the internal resistance of the group of batteries, multiply the internal resistance of each group by the number of groups.

In connecting batteries in series, it does no harm to connect batteries of different makes or different sizes; but in connecting batteries in multiple, in multiple series or in series multiple, you should always use the same size of batteries, of the same make and in about the same general condition. Otherwise, there is likely to be differences of voltage and differences of internal resistance of the different cells in the groups, which would have a tendency to form an internal short circuit within the group fatal to the life of the group.

In telephone work there is rarely, if ever, any necessity of connecting batteries otherwise than in series; but that the reader may become acquainted with the principles involved, the author has shown all of the methods.

To obtain the greatest possible amount of current through any given circuit, the grouping of the batteries must be so arranged that the internal resistance of the battery (the word battery means the entire group of cells) is equal to the external resistance of the circuit. This does not mean that it is the most efficient way of connecting batteries, but simply the way to get the largest amount of current driven through the circuit. For, if the internal resistance of the battery is equal to the external resistance of the circuit, one-half of the energy produced by the

battery is consumed in overcoming its own internal resistance, which gives an efficiency of 50 per cent only, which is not very good.

The average resistance of the primary circuit of a telephone, including the battery and the heavy wire winding (the primary coil of the induction and the transmitter head or microphone) is about 30 Ohms, and the internal resistance of the average battery is about three Ohms. As there are usually two cells of battery of 1½ Ohms each, therefore, the efficiency thus shown is about 90 per cent for only about one-tenth of the energy produced by the battery is used in overcoming its own internal resistance.

Of course, the resistance of the primary circuit fluctuates enormously while one is talking into the transmitter; if the transmitter is a good, sensitive one, it varies from 30 Ohms to three or four hundred Ohms.

The *Voltage* of a battery is *not dependent* upon its *size*, but is dependent entirely upon the kind of materials that go to make up the cell of battery. No matter how small or how large a cell of battery is, using the same materials, its Voltage is just the same.

The *current* which a battery will give out, however, is *dependent* upon the *size* of the cell of battery; or the number of cells in the battery, which are connected in mutiple. By increasing the surface of the plates and increasing the amount of electrolyte or solution in a battery, the active surface is increased and therefore the internal resistance is decreased; this of course, all other things being equal, will increase its output in Amperes of current; but it would in no way have any effect upon the Voltage or pressure.

As to just what takes place when a battery that produces electricity is short-circuited, is a matter that has never been fully understood or explained. Of course it is known that chemical action or substitution takes place; but why that should produce a current of electricity is more than can as yet, with all the science of the world, be fully or even partially explained. It is sufficient for practical purposes that we know the effect it produces and that we know the laws which govern its generation, distribution and control.

CHAPTER IV.

THE PRODUCTION OF ELECTRICITY FROM MECHANICAL MEANS AND THE CONDENSER.

If a magnet be moved to and fro in a coil of wire the circuit of which is closed, a current of electricity will be generated in this coil of wire in one direction when the magnet is approaching the coil; and in the opposite direction when the magnet is leaving the coil.

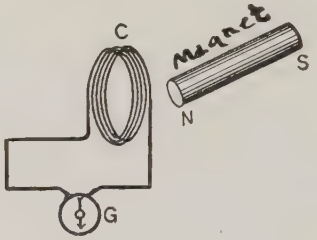


Figure 44.

Figure 44 illustrates this principle. The galvanometer is marked "G" and is included in the circuit so that the impulses of electricity as well as its direction can be noted by the galvanometer. All dynamos including telephone magneto generators are constructed so as to apply this principle to the best advantage.

Figure 45 shows a permanent magnet, showing the way the lines of force circulate from one pole to the other; and it is in virtue of cutting these lines of force with a coil or loop of wire, that electricity is generated by mechanical means. If a loop or coil of wire be held in the hand and swung in a circle so as to present first one end of the coil to the north and then to the south; or if the coil be mounted on an axle, pointing east and west, at right angles to the axis of the coil and rotated so that it would cut a line drawn from the north to the south pole of the

earth, it will generate electricity. If a sufficiently sensitive galvanometer were connected in circuit with this coil every revolution of the coil will be found to generate an alternating current of electricity. In this case, the natural magnetism of the earth would be furnishing the magnetic lines for the coil to cut.

Referring again to Figure 45, it will be seen that the lines flow from one pole to the other just exactly as do the magnetic lines of force flow between the north and south poles of the earth.

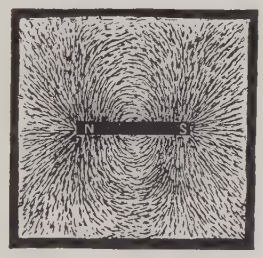


Figure 45.

The earth itself is one large bar magnet, but the lines of force are so much scattered as to be very thinly distributed over the surface of the earth; so that for generating electricity for practical purposes, a permanent magnet or an electro magnet has to be substituted for the north and south poles of the earth; as these magnets furnish lines of force of enormously greater density within the given space in which the armature containing the coils of wire is to rotate.

Figure 46 shows a loop of wire arranged in the magnetic axis of a magnet and mounted on an axle or shaft so as to cut the lines of force that traverse the space between the north and south poles of the magnet. This illustrates in a very simple manner the principle upon which all dynamos operate. All magneto electric generators, for telephone purposes, have the wire wound upon a soft iron core or armature. This concentrates all of the lines of force and causes them to thread themselves through the coils or loops of wire on the soft iron armature, soft iron being the best known conductor of lines of magnetic force.

When this loop of wire rotates, it generates two impulses of electricity, one in each direction for every revolution it makes. The coils of wire, the shaft and the core upon which they are wound are ordinarily called the armature of the generator. The magnets furnishing the magnetic lines of force are called the field magnets. The ends of the magnets which are next to the armature are called the poles of the magnets. There are two kinds of field magnets, permanent field magnets, and electro field magnets.

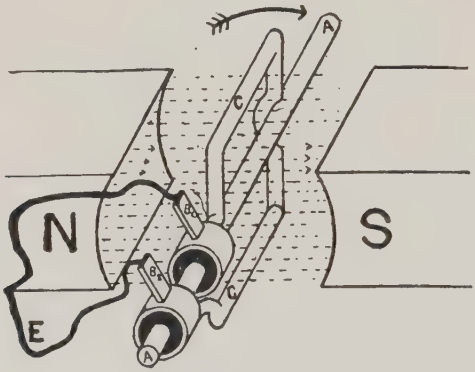


Figure 46.

Permanent field magnets are used on magneto generators. Electro field magnets are made of the softest kind of iron and are wound with a number of turns of insulated copper wire. When electricity is passed through these turns of wire, it strongly excites the magnet, making a much stronger magnet than a permanent magnet; but when the electricity ceases to flow through the coils surrounding the cores of the electro magnet, the magnetism also ceases to exist in the electro field magnet.

Figure 47 shows a cell of battery that has an insulated coil of wire, in its external circuit, wound around a bar of iron; this shows that when the current circulates around this bar of iron through the coil, it produces magnetism in the iron, making of course a north pole at one end and a south pole at the other end. The larger the number of turns of wire, or the larger the amount of current flowing through the coil of wire, the stronger will the

iron bar be magnetised. Up to certain limits it will be magnetised in proportion to the Ampere turns. That is, the number of turns wound around the bar multiplied by the number of Amperes passing through these turns. These Ampere turns taken together are called magneto motive force; meaning the force that moves or causes the magnetism in the iron bar.

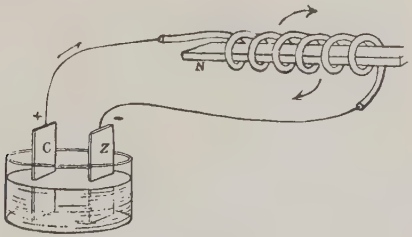


Figure 47.

THE CONDENSER. A condenser is a device that is very much used in telephony, although but little used in the simpler form of telephony, such as rural systems.

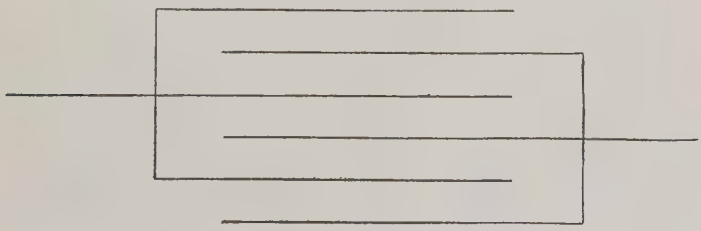


Figure 48.

Figure 48 is a diagramatic picture of a condenser. Condensers in practice are made by alternately laying sheets of tin foil and sheets of mica or thin waxed paper on each other until a stack of them is obtained. Starting from the bottom layer and numbering the sheets of tin foil, all of the odd numbers are connected together, forming one terminal, and all of the even numbers are connected together, forming the other terminal. The sheets of tin foil of these two sides or terminals intermesh with

each other, being separated and insulated from each other by the sheets of mica or waxed paper.

A condenser is capable of absorbing or of allowing current to pass through it by induction from one set of tin foil sheets to the other set. The larger the area of the plates of a condenser, or the closer together they are, the greater is the capacity of the condenser.

All telephone lines are condensers, that is, they have the property of condensing electricity on their surfaces and allowing current to pass from one side of the circuit to the other by induction. If a metallic circuit is used, the outgoing wire is one plate of the condenser and the incoming wire is the other plate of the condenser.

If a grounded circuit is used, the line wire is one plate of the condenser and the earth forms the other plate of the condenser. The capacity, however, of telephone lines as compared to condensers that are regularly made for the purpose, is very small. The plate surface of the lines as a condenser, is only the surface of the wires and the distance apart between the wires is enormous, as compared to the distance between the plates of regular condensers. The plates of a regular condenser are set just as closely together as is possible to have them without incurring the danger of having plates of opposite sides come in metallic contact with each other.

If a direct current, such as from a battery, be applied to the two terminals of a condenser, the condenser will become charged with electricity in quantities depending upon the area of the plate surface or their nearness together; and in Voltage corresponding with the Voltage of the battery that charges it.

A condenser will become instantaneously charged as soon as contact is established between the two terminals of the condenser and the two terminals of the battery or other source of direct current and no further current will flow through the condenser or battery. Should the battery circuit be now broken, the condenser upon being short circuited will give forth the electricity which it has absorbed from the battery. One terminal of the condenser will be charged positively and the other one negatively; and as electricity always flows from the positive to the negitive pole, electricity will pass, upon short-circuiting the con-

denser, from the positive to the negative pole. It is thus seen that a condenser is practically an open circuit for a continuous or direct current after the condenser has absorbed a charge. If, however, an alternating current be applied to the two terminals of a condenser, it will allow the current to pass through it by induction; as the two sets of plates, which we will designate as positive and negative plates, become alternately charged positively and negatively and between every alternation, the current will give back to the circuit charging it, the electricity which it has absorbed. This, of course, is done by electricity passing through it, as above explained, by induction from the positive plates to the negative plates and vice versa. Thus it is seen that a condenser does not make a break in the circuit of an alternating current but that it does make a break in the circuit of a continuous current. It is only for this reason that the condenser is used in telephone work; when a direct current and an alternating current are to be employed in the same circuit, or when an open circuit is wanted for the direct current and a closed circuit for the alternating current.

If a condenser be bridged across the line of a telephone circuit, it will transmit the voice currents and will be equivalent to short-circuiting the line, for the voice currents of a telephone are alternating in character. If the main line should be cut and the condenser inserted in the line in series with the line, then the talking and ringing current would pass through the condenser; as both of them are alternating. Should the condenser be of large enough capacity, that is, have a large enough area of plates and enough of them, it would not make any interference with the service, as the voice currents and ringing currents are both alternating, they would be transmitted through the condenser with but little loss.

Vibratory continuous currents will also pass through a condenser, but not as well as alternating currents.

The effect that capacity, (which is the property of a condenser) has on a telephone circuit is this: suppose on a metallic circuit line 1000 miles long, there be a telephone at each end; now as the telephone line has so much capacity per mile as the vibratory talking current traverses the line, it is continually being short-circuited by the capacity; or in other words, allowed to pass from one side of the circuit to the other all along the entire

length of the line. If the line were too long or its capacity too great, the talking current would be transmitted from one side of the circuit to the other before it would reach the distant telephone. Hence the only limit to extremely long distance telephony is the capacity of the circuit.

CHAPTER V.

COMPLETE SERIES AND BRIDGING MAGNETO BELLS.

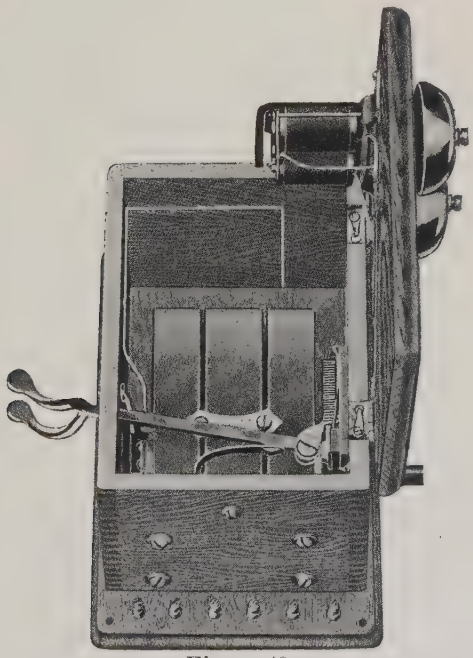


Figure 49.

Figures 49 and 50 show a complete view of a series and bridging magneto bell respectively. The lids of the boxes are shown opened so as to expose to view the ringer, generator and switch-hook. The magneto bell is that part of the telephone which sends out the signal by means of the generator and receives the incoming signal by means of the ringer and gongs.

It also operates the different circuits of a telephone by means of the automatic switch-hook.

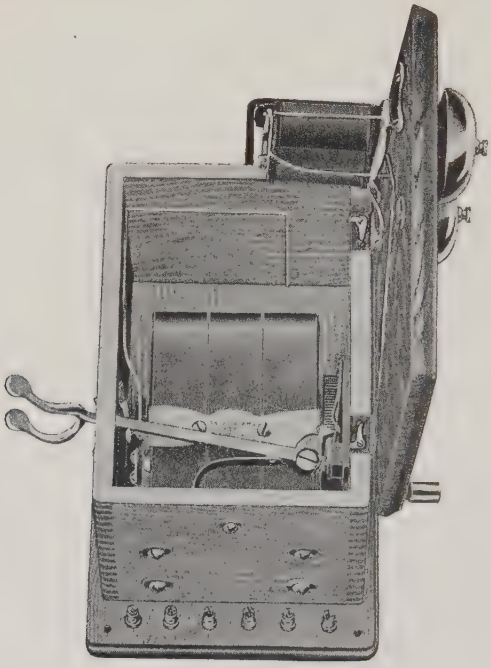


Figure 50.

A magneto bell contains a good deal of mechanical work, a great many moving parts and has, therefore, to be built of the very best quality of material and must be of first class design. Nothing but the very best of mechanical workmanship should be employed in its production, as the magneto bell is subject to more wear than any other part of a complete telephone.

We will describe the magneto bell in its four constituent parts:—

First, the generator.
Second, the ringer.
Third, the switch-hook.

Fourth, the cabinet work, its fittings, binding posts, circuits and connections.

THE GENERATOR. Figure 51 illustrates a complete armature core with its shaft ready to insulate and wind with insulated copper wire. This armature core is made up of a very large number of stampings from the softest quality of Swedish iron. These stampings are then assembled side by side on a highly polished and true steel shaft. They are forced on this shaft friction tight and in addition thereto are keyed, so that they cannot change their position on the shaft.

There are two brass pins going through the wings of the armature core, so as to hold tightly together the different punch-

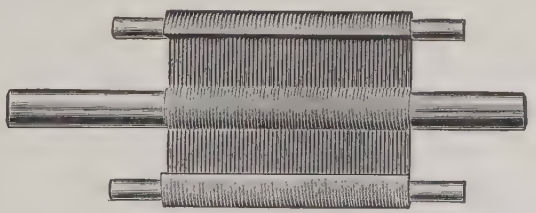


Figure 51.

ings. A hole is drilled into one end of the shaft, (not shown in the illustration) into which a piece of hard rubber is driven and cemented. Through this passes a brass pin which has a wire leading out of it, through a rubber bushing in the side of the shaft, to which wire the outer end of the winding is soldered. The inner end of the armature winding is soldered to a brass pin which is driven into a hole drilled through the armature shaft.

The frame of the armature, and therefore the entire metal work of the generator, form one terminal of the armature winding. The other terminal is insulated by means of a brass pin, insulated from the shaft, and called a commutator pin. Against this commutator pin a flexible spring of German silver presses, to take off the current from the armature and carry it to the line, as shown in Figure 52.

This armature, after being insulated and wound, has a pinion that is fastened to one end by means of a key and machine screw; so that the pinion can be easily put on or taken off. The armature is mounted in brass end plates, which follow on their

outside periphery the curvature of the armature; and they fit snugly into pole pieces which are made of soft sheet iron. These brass end plates have long, highly polished brass bearings, mounted centrally in them for the armature to rotate in.

This armature rotates in close proximity to the inside surfaces of the pole pieces, so as to have the air gap between the armature and the permanent magnets as small as possible. Air offers a very high resistance to the transmission of magnetism; but it is desirable to have all of the magnetism that it is possible

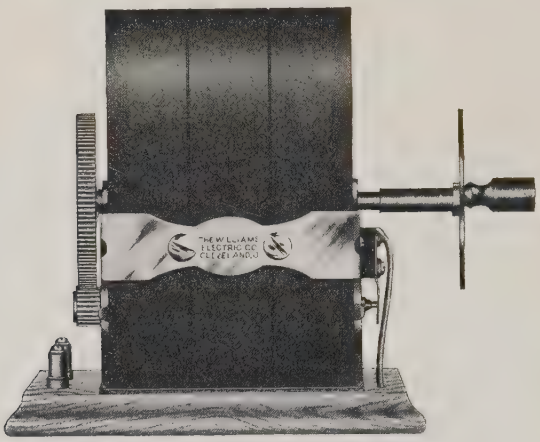


Figure 52.

to get, flow through the armature core and therefore through the windings, to give to the complete generator as much Voltage as possible. On the top end of these brass end plates are provided two long brass bearings for the crank shaft and gear wheel, which turns the armature, to rotate in.

THE SHUNT. All magneto generators, either of the series or of the bridging type, are equipped with what is called an automatic shunt, or automatic cut-in. The shunt is applied to the series generator to provide a by-path or shunt to the armature winding, in order that the armature winding may not be in circuit except when the crank of the generator is being turned.

Figure 53 shows a complete magneto generator without the permanent magnets, thereby exposing the construction and operation of the automatic shunt.

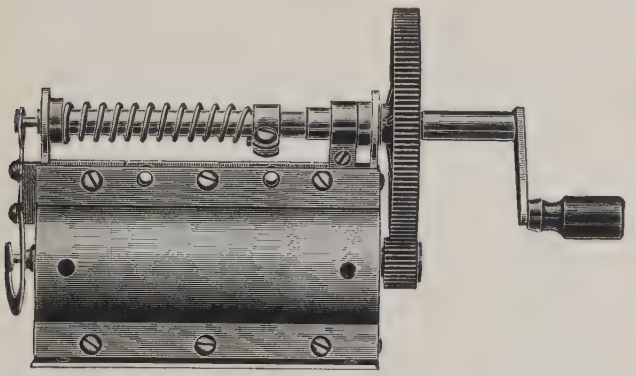


Figure 53.

Figure 54 shows the automatic cut-in on the bridging generator. The principle upon which this shunt and cut-in operates is as follows: there are diagonal slots cut within the brass tube

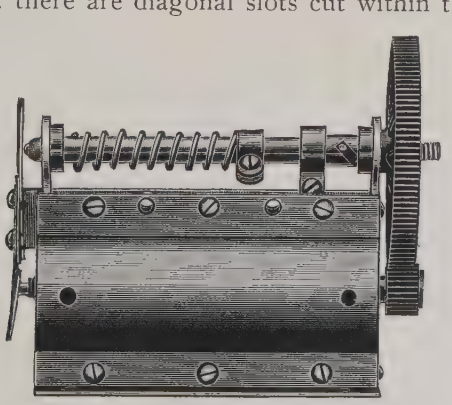


Figure 54.

upon which the large gear wheel is mounted. Through these slots and through the crank shaft, extends steel pins, which fit snugly into the crank shaft and freely through the brass tube.

When the crank shaft is turned, these diagonal slots impart to the crank shaft a longitudinal motion; because the brass sleeve cannot move end ways, owing to a clamp placed around it, which holds it snugly in position against the bearing of the end plate. A wire coil spring is placed around the crank shaft to press against the opposite end plate bearing and the crank shaft. This keeps the crank shaft and its steel pin always at one end of the diagonal slots. When the crank is turned, it compresses this spring and travels longitudinally, and either opens the circuit, if in a series magneto; or closes it, if in a bridging magneto, by allowing the end of the crank shaft to break connection on the series generator, or make connection on the bridging generator.

The mechanical construction, it will thus be seen, is one of the most important parts of a magneto generator; every part must be made to last indefinitely; and should be rigidly and accurately constructed so as not to get out of order.

THE GEAR WHEELS of a first class magneto generator are made of cast brass; and have a wide and true face with comparatively large and deep teeth, both in the pinion and in the large gear wheel which gives them a good wearing surface and a long life.

THE PERMANENT MAGNETS, of a magneto generator, should be made of a high quality of magnet steel; and should be properly hardened and magnetized. The permanent magnets of a generator should never overlap each other; that is, one set of magnets should not be placed over another; because with this construction, the inside magnets, being shorter, would offer less resistance to the return of the lines of magnetic force, from pole to pole, than the outer magnets. Inner magnets have the effect of forming a kind of shunt by-path or leak, which continually robs the rotating armature of a large percentage of the magnetism furnished by the outside set of magnets.

The number of magnets upon a magneto generator should not be less than three; and they should be placed side by side, not overlaping each other. More magnets than three may be used, if desired, as long as they are placed side by side; but any larger number than three magnets does no good except to add more magnetism in direct proportion to the weight of steel that is employed.

The placing of a number of magnets together is called com-

pounding them; and after a set of magnets is triply compounded, there is no further advantage gained by further compounding; but in fact, a disadvantage, as will be presently seen.

CHARGING OF THE PERMANENT MAGNETS. After the magnets are properly hardened, they are placed on a powerful electro magnet and electricity, usually from a dynamo, is used to charge this electro magnet; beginning first with the "U" or bend of the magnet and drawing away from the magnet towards the ends; the intention being to crowd just as many lines of force through the hardened steel as is possible to get. After they are magnetized, they are selected so as to get magnets of equal strength on the same generator. The magnets are carefully tested each one against the other; to avoid having magnets of different degrees of temper go on one generator; for, should there be the slightest difference between the characteristics of the magnets in any way, the weaker magnets of the group would form a return path for the stronger magnets; and would thus rob the armature of the magnetism. From this it will be seen how wrong is the idea of using long and short magnets on the same generator; having them overlap each other, instead of having the bars of steel thick enough in the first place, and placed side by side.

High grade magnet steel tempers at a very low heat and very uniformly; consequently there is no necessity whatever for using thin bars of steel; unless a very low grade of magnet steel is used, which will not temper except in small thin pieces.

Those manufacturers who compound magnets by placing them over each other, offer as their excuse for so doing, that the magnet steel cannot be properly hardened unless in thin pieces. This excuse, however, seems to the author very flimsy indeed. If they would use a high grade of steel, they would have no trouble whatever in tempering it if it was two or three inches thick; for on the battle ships of the United States navy, armour plate is tempered that is 20 or 30 inches thick and tempered uniformly through and through. The grade of steel which goes into armour plate is a much poorer grade of steel than should be used, and generally is used, on first class magneto generators.

It will be noticed by referring to Figure 50 that the magnets, on the generator of the magneto bell there illustrated, in the bridging type, are set very closely together, to utilize all of the

space possible in permanent magnet steel. The magnetism of any generator, dimensions and other things being equal, is proportional directly to the weight of the magnet steel used in it.

On the series generator illustrated, the magnets are much narrower and are set one-fourth of an inch apart; because it is not necessary to have series magneto bells as strong as bridging magneto bells; since series magneto bells are only intended for use where but three or four instruments are to go on one line. Whereas with bridging bells, as many as thirty or forty telephones are frequently placed on one line; and the generator has to be sufficiently powerful to ring all of them at one time. Therefore, advantage is taken of everything to have bridging generators as strong as they can possibly be made, considering the space which they occupy in the cabinet work of a telephone.

THE WINDINGS OF MAGNETO GENERATORS. The winding of a series magneto generator is done with small wire, so as to get a large number of turns around the armature core. Voltage or pressure is required on the series instruments, in excess of what is required on bridging instruments; because they are connected in series with each other and the same amount of current that operates one ringer, passes through the next and operates it; and so on with all the instruments on the line.

A 10,000 Ohm series generator, as ordinarily built by most of the manufacturers of magneto bells, is wound with from three to four thousand turns of wire from No. 34 to No. 36 gauge, depending, of course, upon how powerful are the permanent magnets of the generator. The more powerful the magnets the less number of turns necessary on the armature for a given voltage of the generator.

ON BRIDGING GENERATORS heavier wire is used, sizes from No. 28 to No. 32, according to the resistance ringer that it is intended to work with. The heavier wire, on account of having less resistance, gives out a larger volume of current; and volume of current is what is needed in a bridging generator with sufficient voltage of course to operate the ringers through the necessary line resistance.

The elements which go to make up voltage in either a series or a bridging generator, or in fact, in any dynamo or electro magnetic generator of any kind, are three:—

First, the quantity of magnetism that passes through the armature core.

Second, the number of turns of wire that are wound around the armature core.

Third, the speed at which the armature is rotated.

All of these factors contribute to the creation of voltage or electric pressure. The smaller the air gap between the rotating armature, and the pole pieces (which are really an extension of the permanent magnets) the more magnetism will be conducted through the armature core.

The Voltage increases directly proportionally to the amount of lines of magnetic force passing through the armature windings; and also directly in proportion to the number of turns that are wound upon the armature core; as well as directly in proportion to the speed of rotation if on open circuit. These three factors are all equal in the creation of electrical pressure or Voltage.

CREATION OF ELECTRICAL CURRENT OR AMPERES. Electrical current or Amperes, as previously explained, is a direct result of electrical pressure or Voltage divided by the resistance through which it has to force the current. The current is therefore, the result of the Voltage as applied to the resistance of the circuit; and the armature being wound with heavy wire on bridging generators, unnecessarily has fewer turns of wire within the given space of the armature. Therefore, each turn has less internal resistance than the turns of series generators. The Voltage of each turn, no matter whether wound with fine wire or coarse wire, is the same; but the resistance of the turns wound with heavy wire being so much lower than those wound with fine wire, it is apparent at once, that the heavy wire windings have the greater output in current. Hence the necessity of heavy wire winding where volume of current is wanted.

COMPLETE BRIDGING TELEPHONE RINGER. Figure 55 illustrates a complete bridging telephone ringer. The magnetic circuit of this ringer consists of two upright cores, which carry the windings of wire; the base plate or yoke that connects the cores together at the bottom; and the vibrating armature. All of these parts which constitute the magnetic circuit are made of the very softest Norway iron obtainable; as this grade of iron has less magnetic resistance and is very susceptible to magnetization. There are two brass up-rights which sup-

port a brass bridge which the vibrating armature is mounted upon; and there are two nuts on the ends of these rods that are used to adjust the length of the stroke of the clapper. The space between the vibrating armature and the ends of the magnet cores is about one sixty-fourth of an inch.

There are two little brass rivets placed in this vibrating armature that strike the cores and prevent the armature from coming into magnetic contact with the cores; for if it did, it would

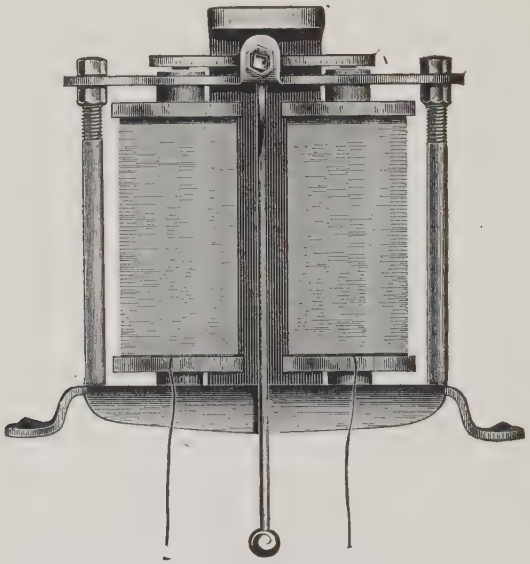


Figure 55.

stick and would not vibrate, by becoming too strongly magnetized. The adjustments, of the little conical pointed pivot screws that support the vibrating armature, must be set just so that they do not bind the armature and prevent its free vibration; but they should be screwed in enough not to allow two much loose play, but as little as is barely perceptible.

The part that the permanent magnet of a ringer plays is to polarize the vibrating armature throughout, giving to it, magnet-

ization of constant polarity. Now the windings on these cores are in such direction that if a direct current were passed through them in one direction, it would make, for example, the right hand core tip of north polarity and the left hand core tip of south polarity. If this current were reversed and passed in the opposite direction it would polarize the core tips oppositely. Thus the right hand one would be of south polarity and the left hand one of north polarity. Now inasmuch as the current furnished by the generator that operates these ringers is alternating, (one impulse is in one direction and the next impulse is in the other) as long as the generator is turning, we get a succession of rapid changes of polarity of the core tips of the ringer; and inasmuch as the vibrating armature is magnetized to constant polarity by the permanent magnet, the armature does not change its polarity, whether current is passing through the ringer coils or not; but remains permanently polarized in one direction. Inasmuch as one law of magnetism is that like poles repel each other and unlike poles attract each other, it will be seen that the vibrating armature is always being repelled, either from one core tip or the other; and being attracted by one core tip or the other according to which way the impulse of current is passing through the ringer, it being attracted by one and repelled by the other.

The stronger the permanent magnet of a telephone ringer, the harder will it strike; that is, the louder noise it will make. If there is no magnetism at all in the permanent magnet, it will not ring no matter how strong the alternating current that is passing through the magnets.

This is the principle upon which all telephone ringers operate; and the reason one form of telephone ringer is better than another is simply a question of mechanical rigidity, quality of material, durability of construction, ease and permanency of its adjustment.

It will be noticed, by referring to the illustration of this complete ringer, that its mechanical rigidity seems to be about all that could be desired; the heavy base plate is trussed so that it cannot bend or give, should the cabinet work warp or shrink; besides the top end of the magnet cores passing through holes in the brass yoke piece further braces it so that it is impossible for this ringer to get out of adjustment either in shipment, rough handling or shrinkage of the cabinet work.

THE SWITCH HOOK. Figure 56 shows an automatic switch-hook of good design. The function of the switch-hook is to change the connections upon taking the receiver off the hook. It automatically closes the primary circuit of the telephone, which circuit includes the batteries, the primary windings of the induction coil and the microphone or "transmitter head;" and it also connects the secondary circuit which comprises the telephone receiver and the secondary windings of the induction coil to the line.

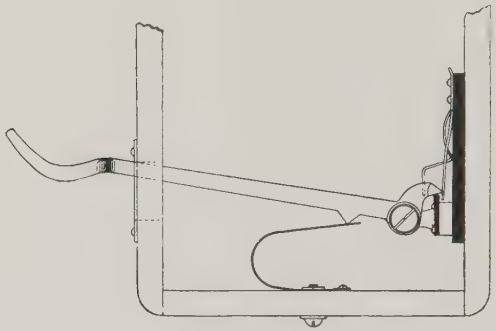


Figure 56.

Switch-hooks are usually made of cast brass and are nickel-plated. The spring contact upon which the hook makes connection should be of some non-corrosive metal and very springy in temper. The hook lifting spring should be of tempered steel. A good many manufacturers depend upon the joint in the switch-hook carrying current from the hook to the hook contacts; but in this switch-hook it will be noticed that a coil spring of fine wire is soldered on to the switch-hook and from thence on to one of the circuits of the switch-hook, to make a shunt or by-path around the hinge joint in the hook. This is a very wise

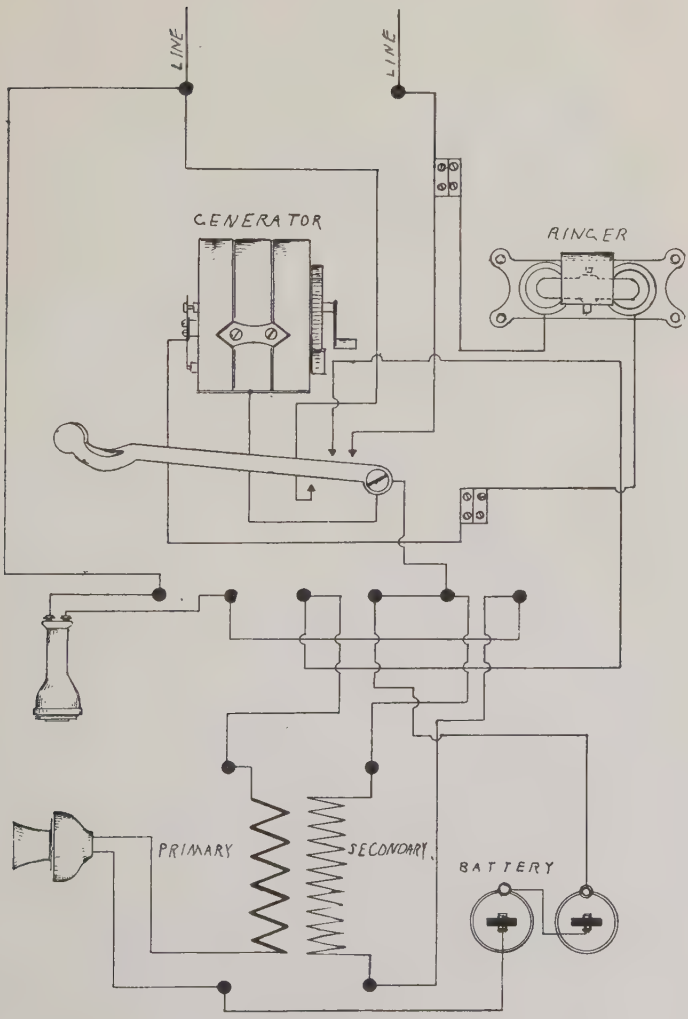


Figure 57.

precaution as it renders loose and imperfect contacts between the hook and the rest of the circuit impossible.

BINDING POSTS AND GENERAL FITTINGS. The binding posts of the magneto bells illustrated have stems which are a part of them and which pass entirely through the cabinet work and are fastened with nuts screwing on these stems. The binding posts are corrugated so that they cannot turn. The wiring is laid into grooves sawed in the bottom of the box and is soldered on to the solid stems of the binding posts, making a very reliable form of connection between the binding posts and the wiring.

All contacts on any magneto bells should be soldered contacts. The best way to do this is to solder them directly to the binding post stems, as is done with the magneto bells illustrated.

These magneto bells are not equipped with lightning arresters, as the old form of metal plate lightning arrester is now obsolete; and it is best to use separate lightning arresters, such as are herein illustrated and described later on.

WIRING CIRCUIT OF A SERIES MAGNETO BELL AS APPLIED TO A SERIES TELEPHONE. Figure 57 shows the wiring diagram of a complete series magneto bell manufactured by the Williams Electric Telephone Company. It will be noticed that when the hook goes up, the ringer coils are shunted; a by-path is provided for them, so that one does not have to talk through the ringer coils of the telephones in use. The ringer and generator are, of course, in the same circuit in series with each other; and the generator winding is normally shunted by the automatic shunt on the generator; so that an incoming call does not have to pass through the high resistance winding on the generature armature.

The action of turning the crank to send out a signal opens this shunt and in this way delivers the current from the generator armature through the ringer to the line. This ringing is, of course, done when the receiver is hanging on the hook. When the switch-hook goes down by hanging up the receiver, the secondary circuit is shunted and the primary circuit is opened. The value of shunting the secondary circuit is that if lightning should strike the line, it could not in any way get into the secondary windings of the induction coil or the receiver and burn them out. Many telephones, however, are wired on the plan of open-

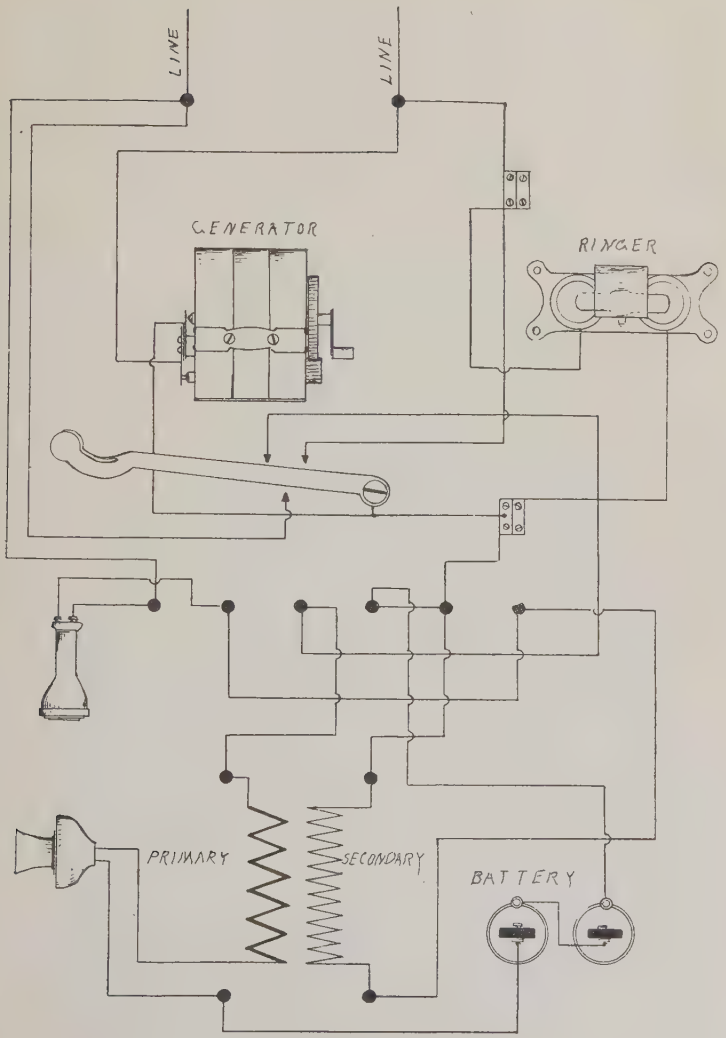


Figure 58.

ing the secondary circuit as well as the primary circuit when the receiver is on the hook; but experience has shown that where telephones are wired on that plan, the induction coil frequently burns out from lightning. With the principle of connections as shown in the diagram (Figure 57) it is impossible for lightning to do any injury to the induction coil or receiver, unless it should happen to strike the line when the receiver was off the hook and the telephone in use.

Figure 58 shows the wiring diagram of a complete bridging telephone as manufactured by The Williams Electric Telephone Company. In this diagram it will be noticed that the ringer itself is bridged across the line terminals when the switch-hook is down. When the switch-hook goes up, the ringing circuit is first opened and then shunted; so that one does not have to talk through the ringer coils or waste any talking current by having the ringer of the telephone in use bridged across the line. A further advantage of this system of wiring is that a subscriber must leave the receiver on the hook or he cannot be called up. This prevents the subscriber from carelessly leaving the receiver off the hook and running down or using up the battery, as would very shortly occur if he were careless in this respect; but when he knows that he cannot be called unless his telephone is in the proper position to receive a call, he is always careful to hang the receiver on the hook. The proper time to send out a signal from the telephone is, of course, when the receiver is on the hook.

The generator is bridged across the line but is not actually connected to the line on both sides except while the crank is being turned and a signal being sent. The automatic cut-in closes the circuit, bridging the generator across the line when the crank is turned and opens the circuit; and cuts the generator off of the line when not in use. The secondary circuit is also shunted, as in the series diagram and for reasons as previously explained.

In both these diagrams the transmitter and battery circuits are shown. The heavy black dots represent binding posts. It will be noted that there are six of them on the lower part of the magneto bell. The four of them in the lower part of the diagram represent the transmitter base binding posts.

The zig zag lines which are marked "primary" and "secondary" represent the heavy primary winding and the fine wire

secondary winding of the induction coil. The top dots represent the line binding posts and are on top of the magneto bell.

For the sake of familiarizing the reader with tracing circuits, we will trace out the ringing and talking circuit of this bridging telephone diagram.

We will assume that the hook is down and in contact with the back contact or lower arrow head, which represents that contact spring which the hook touches when down. Suppose an alternating current of electricity were to come in on the right hand line wire. It could not follow the line down and pass through the generator for the automatic cut-in being opened on the generator, would not allow it to pass through the generator; so it would have to go to the hinge and from there it could not reach the switch-hook through that contact point, as the switch-hook would not be in contact with it. It would, therefore, have to go through the ringer; and from the ringer it would connect with the switch-hook proper and get on to the back contact spring which is in contact with the switch-hook; and traverse that wire up to the left hand line binding post and then on back to the generator which sent in the current.

We will now suppose that the subscriber has answered the call by taking the receiver off the switch-hook and placing it to his ear. The switch-hook now rises up and parts with the bottom arrow head or back contact spring and makes a contact on the two top arrow heads or contact springs.

Now we will start with the battery current. Where the wire leaves the left hand side of the battery, or its carbon or positive terminal, which connects with one of the binding posts on the transmitter base (the lower left hand one in the illustration) into the microphone or "transmitter head," passing through it and the primary winding of the induction coil; from there to the upper left hand binding post of the transmitter base and thence to the third binding post from the left hand side of the magneto bell; and from there on up to one of the hook contacts, being the upper left hand arrow head, making contact with the hook, passing off the hook to the coil spring connection, which connects the hook with the circuit, and passing to the hinge. From that down to the second binding post from the right hand side of the bottom of the magneto bell; from there over to the third binding

post from the right hand side of the magneto bell and from there on down to the negative terminal of the battery.

Now it will be seen that the primary circuit is closed and when the subscriber talks, he fluctuates this current, which in turn induces fluctuations of current in the secondary winding of the induction coil, which, of course, is wound over the primary winding.

We will assume that this secondary circuit starts from the lower end of the secondary winding, which is the lower right hand binding post in the illustration. From there up to the right hand binding post on the bottom of the magneto bell; thence over to the second binding post from the left on the magneto bell; from here through the receiver to the left hand binding post of the magneto bell. From there to the left hand line binding post of the magneto bell and on the line through the subscriber's receiver and secondary coil that called up and onto the right hand line; in on the right hand line to the right hand binding post; from there on past the hinge on down to the right hand top arrow head, which represents one of the hook contact springs. From there on to the hook, as the hook is in contact with the spring when up. From the hook via the hinge to the second binding post; from the right hand side of the magneto bell, and from this binding post, down to the upper right hand binding post of the transmitter base; and from thence into the secondary coil, showing a complete closed circuit for both the primary and secondary when ready for talking.

RATING OF MAGNETO BELLS. A great deal of confusion exists as to the proper way of rating series and bridging magneto bells as to their strength. To avoid confusion in this matter, below is given the proper way of rating magneto bells.

RATING OF SERIES MAGNETO BELLS. Series magneto bells are rated by the number of Ohms of line resistance that they will ring through satisfactorily; thus a 10,000 Ohm series magneto bell should ring through 10,000 Ohms of line resistance connected across its terminals. In the series bells, the current goes through the resistance and also through the ringer; as the resistance, the ringer and the generator are all connected in series. This 10,000 Ohm rating capacity does not in any way refer either to the resistance of the ringer or to the

resistance of the generator; but refers only to the resistance that the magneto bell will ring through.

RATING OF BRIDGING MAGNETO BELLS. Bridging magneto bells are rated by the resistance of their ringers. Thus a bridging bell, with a 1000 Ohm ringer, is called a 1000 Ohm bridging; or with a 1600 Ohm resistance ringer, a 1600 Ohm bridging; which is the number of Ohms of wire there are wound upon the ringer.

Some manufacturers have been calling their bridging bells 50,000 Ohm generators and 100,000 Ohm generators, etc., etc., all of which is a very meaningless term; as a generator that might ring through 50,000 Ohms with a certain resistance ringer, would not ring through 25,000 Ohms with a great deal lower wound ringer; and might ring through 100,000 Ohms with a still higher wound ringer; so that, unless the resistance of ringer is referred to in rating generators, the term "50,000 Ohm generator" or "100,000 Ohm generator" is absolutely meaningless. Bridging bells are not intended to work in series with each other and will not work in series with each other, as the resistance of the ringers is too high. Therefore, a new system of rating should be devised for bridging bells.

The author suggests the following system which has been tried and is in use by one manufacturer of magneto bells and which is giving very satisfactory results.

Figure 59.

Figure 59 shows a resistance coil, a line wire and ten telephones bridged across the line as in regular line connections. The resistance of the resistance coil is 1000 Ohms and is wound non-inductively; that is, the wire is wound back on itself so as to have no magnetic effect in the coil. (All resistance coils for alternating or vibratory currents should be wound non-inductively.)

The resistance coil is shown between the end telephone and the rest of the group of ten telephones; so that the generator being tested must give sufficient voltage to drive the current through this resistance coil; and then have sufficient voltage and amperage to divide the current among the ten ringers and ring them loudly and strongly.

This 1000 Ohm resistance coil represent line resistance and is equal to a grounded return circuit of 25 miles of No. 12 steel telephone wire or a metallic circuit of $12\frac{1}{2}$ miles of No. 12 steel telephone wire. This is the best possible test for showing not only the voltage of the generator, but also its quantity output in amperes; as in bridging telephone generators, voltage and quantity are both required; whereas in series telephone generators, voltage only with but a very slight amount of current is required. If 1000 Ohm bridging telephones are to be tested, 10 of them should be bridged across the line and work satisfactorily. If 1600 Ohm telephones are to be tested, sixteen of them should be bridged across the line and work satisfactorily. If 2500 Ohm telephones are to be tested, twenty-five of them should be bridged across the line. If 3500 Ohm telephones are to be tested, thirty-five of them should be bridged across the line, and so on. In other words, for every one hundred Ohms increase in the ringer resistance of the telephones, an extra telephone can be added to the line without in any way impairing the ringing of the telephones, provided, of course, that the generators are properly built and wound. Now, if a 500 Ohm resistance coil is used instead of a 1000 Ohm resistance coil, twice the number of telephones should be rung on the same line; and if only a 250 Ohm coil is used instead of 1000 Ohm coil, then four times the number of telephones should be rung on the same line. In other words, the shorter the line, the larger the number of telephones can be bridged across the line and work satisfactorily, and the longer the line, the fewer the number of telephones can be bridged across the line and give satisfactory ringing service. If a 2000 Ohm coil is used, then only five 1000 Ohm telephones can be bridged across the line; and only eight 1600 Ohm telephones, and twelve 2500 Ohm telephones, and seventeen 3500 Ohm telephones. This is a much more severe test than actual line conditions, as in actual line conditions, the resistance is distributed

along the line between the various ringers instead of all being in one place.

Below is given a table showing the capacity or rating of bridging magneto bells on the above system of testing; which we will designate as the One Hundred Ohm Multiplying System; meaning that as many telephones can be operated on a line of 1000 Ohms resistance as there are hundreds of Ohms resistance in the ringer. Thus 1600 Ohm should represent 16; 2500 Ohm should represent 25, and so on.

BRIDGING TELEPHONE RATING TABLE.

Resistance of ringer.	Resistance coil equal to 25 miles line wire— No. 12 steel.	Number of Telephones on line.
1000 Ohm	1000 Ohm	10
1600 Ohm	1000 Ohm	16
2500 Ohm	1000 Ohm	25
3500 Ohm	1000 Ohm	35

Resistance of ringer.	Resistance coil equal to 50 miles line wire— No. 12 steel.	Number of Telephones on line.
1000 Ohm	2000 Ohm	5
1600 Ohm	2000 Ohm	8
2500 Ohm	2000 Ohm	12
3500 Ohm	2000 Ohm	17

Resistance of ringer.	Resistance coil to 12½ miles line wire— No. 12 steel.	Number of Telephones on line.
1000 Ohm	500 Ohm	20
1600 Ohm	500 Ohm	32
2500 Ohm	500 Ohm	50
3500 Ohm	500 Ohm	70

It takes a first class generator to withstand the test according to the above mentioned system; and the ringers should ring loudly and strongly under this system of testing or else the telephones be rejected. The above mentioned table is given for the benefit of the purchasers of telephones so as to give them some accurate means of determining the strength of the instruments which they purchase.

1000 Ohm resistance coils, or coils of any resistance, can be obtained of almost any electrical supply dealer or manufacturer; and all that is necessary is to connect the 1000 Ohm resistance coil between one telephone and the rest of the telephones to be tested; so that it is a very easy matter to test in this way the ringing power of telephones that are bought, and the purchaser will be able to assure himself of the quality of the telephones he is purchasing.

CHAPTER VI.

THE ADVANTAGES OF HIGH WOUND, OVER LOW WOUND BRIDGING RINGERS.

Bridging ringers are wound to high resistance for the following reasons:—

First, to have sufficient self-induction to prevent them from being a short circuit to the talking current.

Second, so as to wind the cores with a large number of turns of wire, which, of course, requires smaller wire; incidentally and necessarily high resistance, as the more turns that a ringer has, the less quantity of current has to circulate through these turns for a given mechanical effect.

Third, so as to render the proportion of the ringer resistance comparatively high as to the line resistance; which causes more uniform and equal distribution of current among the ringers that are bridged across the circuit.

To illustrate this point we will assume as an example that there are ten telephones bridged across the line and that the line is a grounded circuit line of 1000 Ohms resistance; (this would equal about 25 miles of No. 12 steel telephone wire) and that the generator with which these 1000 Ohm telephones are equipped, is capable of furnishing a current of one-half of an ampere on short circuit at fifty volts pressure, which represents a powerful modern generator for 1000 Ohm bridging telephones.

Now inasmuch as each ringer has 1000 Ohms resistance and the Voltage which the generator has is 50 Volts, by applying Ohms law, we find that 50 volts will drive through 1000 Ohms one-twentieth of an Ampere. By dividing the Voltage by the resistance, we, of course, get the current that flows. The ten ringers would therefore get ten times one-twentieth of an ampere which equals ten-twentieths or one-half of an Ampere which would be all of the possible output of the generator referred to. The example just given has not taken into account any resistance of the line wire between telephones. Now suppose we had a line 25 miles long and with ground return circuit of 40 Ohms to the

mile. If a telephone at one end of the line should ring up, every ringer would receive different amounts of current, depending upon the length and resistance of line wire that would be between it and the calling generator. The one on the farthest end of the line would have 1000 Ohms of line wire to be rung through in addition to the 1000 Ohms of the ringer itself, making 2000 Ohms. Now this ringer instead of receiving one-twentieth of an Ampere, would receive 50 Volts divided by 2000 Ohms which would be one-fourtieth of an ampere, and the various ringers between the two extreme ends would receive various amounts of current, ranging between one-twentieth of an Ampere and one-fourtieth of an Ampere, according to their distance from the calling generator. To overcome line resistance in practical operation, the ringers themselves have to be made sensitive to very small currents; so they will operate and ring loudly on a great deal smaller current than their own generator would furnish them on a short circuit. Now, taking this end ringer into consideration, (the farthest one from the calling generator) it will be seen that out of the 2000 Ohms of total resistance, the ringer would represent 1000 Ohms or just one-half; therefore, receiving but one-half of the energy that it would receive without line resistance.

We will take this same case, only substituting 3500 Ohm ringers for 1000 Ohm ringers. Now each ringer would receive the pressure of fifty Volts, if there was no line resistance taken into consideration; a current of one-seventieth of an Ampere would pass through each ringer. Divide 50 Volts by 3500 Ohms which equals one-seventieth of an Ampere, which is between one-third and one-fourth as much current as a 1000 Ohm ringer receives under the same conditions. Now, while this receives a great deal less current, it requires a great deal less current to operate it, for the simple reason that it has a great many more turns of wire wound around its cores than has the 1000 Ohm ringer. When it comes to distributing this current along the line to the different ringers, the line wire has 1000 Ohms between the two ends and the ringer has 3500 Ohms. Therefore, the total resistance of the line including the end ringer would be 4500 Ohms, 3500 Ohms of which is represented by the ringer proper. Therefore the end ringer would receive 3500/4500 of the energy that it would receive without the line resistance.

The 1000 Ohm ringer in the same position, would receive but 1000/2000 or just one-half of the energy, while the 3500 Ohm ringer would receive almost seven-ninths of the energy applied to the line to ring this ringer. Of course, the 3500 Ohm ringer would receive more current in actual practice; as the generators that are intended for them are wound for higher Voltage than are the generators for 1000 Ohm ringers.

Furthermore, this is not all of the advantage obtained by using high resistance bridging ringers. As their resistance is considerably higher in proportion to the resistance of the line, it will be seen that they have the effect of making the current distribute itself more *uniformly* among the different ringers. Therefore there is less variation in current between them, and consequently the efficiency is greater; making it possible for a much larger number of bridging telephones to be placed on the same line, besides making the talking service better. Every ringer forms a leak across the line and takes some of the talking current away from the instruments that are in use, although on high wound ringers this amount is very trifling and is not enough to be noticed. With low wound ringers such as 1000 Ohms or less resistance, this leakage of talking current through the different ringers becomes very noticeable; and where two or three heavily loaded lines are connected together with low wound ringers upon them, the talking efficiency is cut down considerably.

CHAPTER VII.

THE TRANSMITTER.

The transmitter of a telephone in the general acceptation of the word comprises the microphone or "transmitter head," the induction coil and the swinging arm or other means for holding the transmitter head in position to give service.

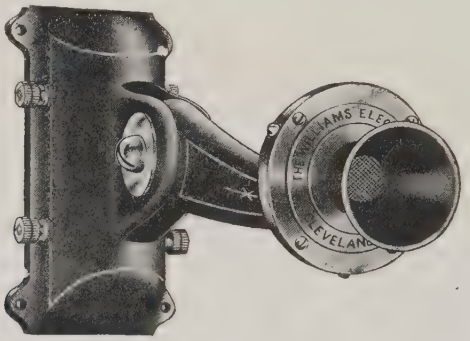


Figure 60.

Figure 60 shows a complete long arm transmitter. The most important part of any telephone (if any one part may be said to be more important than another) is the microphone. The qualities of a first class microphone should be sensitiveness, distinctness of tone, and volume, and its ability to maintain these qualities indefinitely.

The principle upon which a microphone acts is to impress upon the direct continuous current flowing through it, the characteristic vibrations of the voice.

A transmitter to be durable should comprise as few parts as possible; should not have any delicately made contacts or springs that are likely to corrode and increase the non-variable or dead resistance of the transmitter. The diaphragm should not have

anything suspended to or hanging from it that will impede its vibrations.

All contacts should be made as rigidly and durably as possible to keep the dead resistance down to the lowest possible point; so that the only resistance in the microphone is that resistance which is *variable;* the resistance of the granular or globular carbon that is between the two electrodes, which are the diaphragm and back electrode.

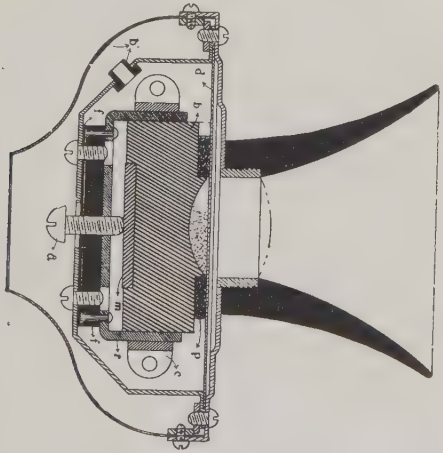


Figure 61.

Figure 61 shows a sectional view of a carbon microphone.

Figure 62 shows a front view of the same with the cap of the diaphragm removed. Referring to Figure 61 (b) is the solid back carbon electrode; (d) is the carbon diaphragm; (p) is a pad of the finest quality of flexible felt; (c) shows one-half section of the split steel clamp that grips the back electrode in the brass receptacle (r); (a) is an adjusting screw for raising or lowering the back electrode. All of these parts are assembled into a box cup which forms a seat for the diaphragm. The carbon diaphragm is clamped between the front cap upon which the entire base is screwed by four machine screws; the inside surface of this cap and the upper surface of the box cup being accurately faced

in a machine so that there is a true and level surface for the diaphragm to rest upon; thus clamping the diaphragm entirely around its outer circumference, holding it straight and true. In assembling this transmitter, the carbon block is raised by means of an adjusting screw (a) until it just barely lifts the diaphragm away from the face of the box cup; just so that there is a slight pressure between the diaphragm and the felt pad. This felt pad seems to dampen the vibrations of the diaphragm and at the same time holds into position the granular carbon. It will be

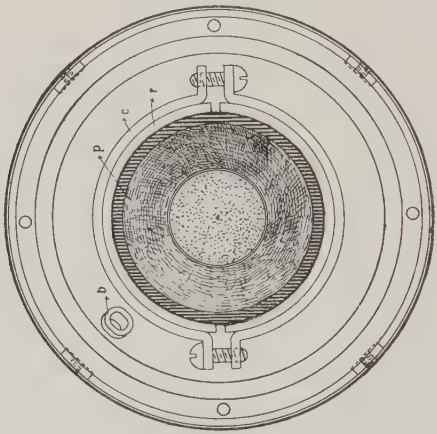


Figure 62.

noticed that the cavity in the back electrode, or receptacle for holding the granular carbon, is very shallow in depth; and is raised above the surface upon which the felt pad rests. The object in this is to have the felt pad of considerable thickness so as to give it elasticity. The object in having the carbon receptacle so shallow is to remove all unnecessary resistance from the transmitter, the entire variable resistance is intended to be right in this receptacle; so that when talking into the transmitter, the entire resistance of the transmitter is varied and, therefore, greater sensitiveness is obtained. Furthermore, there is not enough granular carbon in this receptacle to ever pack or clog. The transmitter is made moisture proof by having an oiled silk

diaphragm placed over the carbon diaphragm to prevent moisture from the breath penetrating it.

The current, in passing through the transmitter, follows a flexible wire through the insulated bushing (D) to the brass receptacle (R); and to the transmitter terminal that is soldered on to the frame or box cup (X); the current then passes into the carbon back plate and from the carbon plate through the granular carbon into the diaphragm; from the diaphragm to the brass receptacle (K) and thence on through to the rest of the circuit. This receptacle is filled with carbon so as to be about two-thirds full when in position for talking, as the illustration shows. It is very plain, that when talking, the resistance of the granular carbon will be varied by being vibrated, and it will be vibrated in exact unison with the voice, and as its resistance varies, it will vary the current in the circuit passing through it, the battery and the primary coil of the induction coil. Now, the more this current can be varied by the least volume of sound, the more sensitive the transmitter, the better the results on long distance talking and the better the results in talking with weak batteries. The principle of all transmitters is exactly the same, that of varying or fluctuating an electric current by the voice, and that transmitter which obtains this object to the greatest extent and in the most simple and durable manner is the best transmitter.

THE INDUCTION COIL. All transmitters for long distance talking are equipped with induction coils. An induction coil is a device for increasing the voltage or pressure of the talking current, to give it ability to penetrate high resistances. In addition to this increase of voltage, an induction coil also increases the vibratory effect of the primary current, making an alternating current out of it. To illustrate this point, we will refer to Figure 63.

The heavy horizontal line represents the neutral point where there is no current passing. The arrow pointing upwards designates one direction in which the current is traveling, which we will call positive; and arrow pointing downward shows the current traveling in the opposite direction, which we will call negative. The jagged and vibratory lines represent the waves or fluctuations of current. The primary current, it will be noticed, fluctuates just on the upper side of the horizontal line, showing

that it does not change its direction, but merely increases and decreases in strength.

The secondary current, which is drawn in finer lines and to the right of the diagram, will be noticed to follow the fluctuations of the primary current; and it will also be noticed it crosses the horizontal or neutral line going below it, showing that the secondary current has the same characteristics as the primary current, but that it is alternating in character. It starts, for example, from zero point, going in a positive direction, and then coming down to zero and goes in a negative direction, showing it to be of a much wider range of vibration; which, of course, makes it more suitable for the attraction, repulsion or vibration of the receiver diaphragm. This, of course, is just what is wanted to make a telephone talk loudly and clearly.

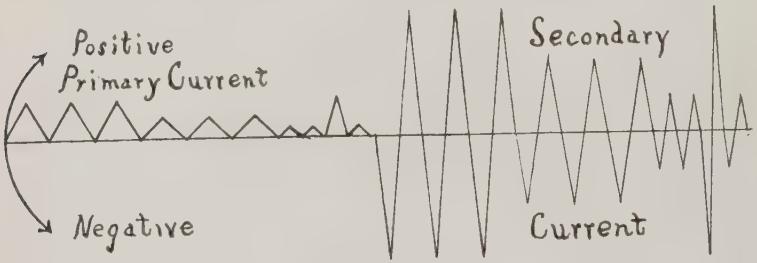


Figure 63.

An induction coil has soft iron wire for a core which is surrounded by a winding of heavy wire usually from No. 18 to No. 24 of comparatively few turns of wire, (from 150 to 600 turns.) The secondary winding is placed over the primary winding and is wound with fine wire so as to have a large number of turns. Induction coil secondaries are wound with from No. 30 to No. 36 wire, from one to four thousand turns. The reason there is so much variation in the winding of the primaries and secondaries of induction coils of different makes is because the primary coil of any induction coil has to be wound in accordance with the resistance of the microphone with which it is to be used.

There is a certain ratio of resistance between the microphone and the primary winding that gives the best results with each type of microphone.

This winding is determined experimentally in designing the coil, for any certain make of transmitter. The usual resistance of the primary winding runs from one-half an Ohm to one and one-half Ohms and of the secondary winding from 50 to 500 Ohms. Two hundred and fifty Ohm secondaries are practically the standard, as windings of this resistance have sufficient volume and raise the Voltage sufficiently for all ordinary purposes of bridging or series telephones.

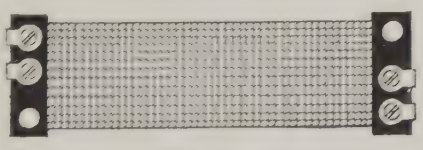


Figure 64.

Figure 64 illustrates a complete induction coil that works in connection with the transmitter just described. This induction coil has a three-eighths inch iron wire core made of the softest Norway iron wires which are straightened and cut to the proper length and thoroughly annealed. These fine wires are driven into a tube of paper fibre which insulates them from the primary winding. On this fibre tube are two fibre end pieces that carry the terminals of the coil and provide means for its attachment to the transmitter base. Over this fibre tube is wound the primary winding. This primary winding is then carefully insulated by having paper wound over the top of it and then over this is wound the secondary coil. The secondary winding of these induction coils have paper between every layer so as to insulate layer from layer, as there is considerable Voltage developed in each layer. Paper should be used between layers to make the insulation better than would be given by the mere insulation on the wire. These induction coils are especially designed for the transmitter illustrated and give excellent results.

CHAPTER VIII.

THE RECEIVER.

Figure 65 shows a complete double pole telephone receiver of a modern type.

Figure 65.

The function of a receiver is to be acted upon by the vibratory alternating current of electricity coming over the line from the transmitter of the party who is talking, and to reproduce from this vibratory current of electricity, a vibration in the air in exact harmony with the vibrations of the current. This is done by the use of an iron diaphragm, which is stamped out of ferotype plate, and is attracted and repelled from the permanent magnet of the receiver, containing the bobbins; this sets up vibrations in the air thus creating sound that is audible to the ear. The outer casing of the receiver is made of the very best quality of vulcanized rubber which has moulded into it a brass ring (as shown in Figue 66.)

Figure 66.

which is accurately machined, faced off and threaded, to produce a more level and truer surface for the diaphragm to rest upon than can be made by facing off the rubber shell.

Figure 67 shows the receiver magnet which straddles the two bobbin cores, imparting to them all of its magnetism. This magnet is made round on the outside so as to fill all of the available space within the receiver shell with magnet steel.

The two bobbin cores are forced down through two slots in a circular disc, which circular disc has six springs formed around its outer periphery. There are also three screws which fasten the disc and bobbins to the shell which are also used for adjustment. The three screws, as shown, screw into the hard rubber shell, and by turning them to the left or right, against the tension of the springs, make the receiver adjustable for any air space that is required between the diaphragm and the core tips. The spools, or bobbins, are thoroughly insulated before being wound, and are then wound with 750 turns each of No. 36 silk insulated magnet wire, giving to the two bobbins a resistance of about 100 Ohms. The core tips should be about one-sixty-fourth of an inch below the level of the diaphragm seat, so as to be very close to the diaphragm, yet sufficiently far from it, not to

be struck by the diaphragm in its vibrations. If any dirt or grit gets between the receiver diaphragm and the core tips, or if the diaphragm should touch the core tips in its vibrations, it will make the sound have a faint and squeeky effect. Dirt will sometimes collect at this point and entirely clog up the diaphragm, so that it cannot vibrate. When this is the case, the cap should be unscrewed by turning it to the left, and the dirt and grit wiped off of the core tips and the diaphragm replaced.

The two things about a receiver which make it sensitive and powerful are: first, the strength of the permanent magnet; sec-

Figure 67.

ond, the number of turns of wire that are around the bobbins. The most necessary thing, however, is to have a very powerful permanent magnet in the receiver. Then the diaphragm will respond to the faintest kind of currents circulating through the magnet bobbins. And the quality to be looked after in a receiver is rigidity of construction and general solidity, as a receiver frequently gets dropped and slammed around, getting some very rough usage and should be built sufficiently strong to withstand it.

All hard rubber receiver shells expand and contract with change of temperature at a much greater rate than does the steel in the permanent magnet. Consequently, some provision has to be made so as to keep the receiver always at the same adjustment, no matter how hot or how cold the temperature may be. Therefore, the back end of the "U" of this magnet is fastened to the binding post end of the receiver shell; the bobbin cores are fastened to the diaphragm end of the receiver shell, and the joint between the cores and the magnet is a telescopic joint; that is,

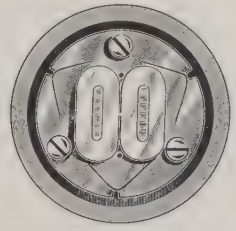


Figure 68.

when the receiver shell expands and contracts, it will cause the magnet to slide one way or the other over the side surface of the cores, and compensate for all variations in expansion and contraction, holding the adjustment at all times the same.

There is considerable air space back of the diaphragm of this receiver, which is also a very good thing. This air chamber acts somewhat on the principle of a resonater, making it easier, of course, for the diaphragm to pick up the vibrations from the fluctuations of magnetism in the core tips, produced by the fluctuations of current passing through the windings of the cores.

CHAPTER IX.

COMPLETE TELEPHONES.

Having described the various parts that enter into a complete telephone, we will illustrate in this chapter a few of the most popular types of complete telephones.

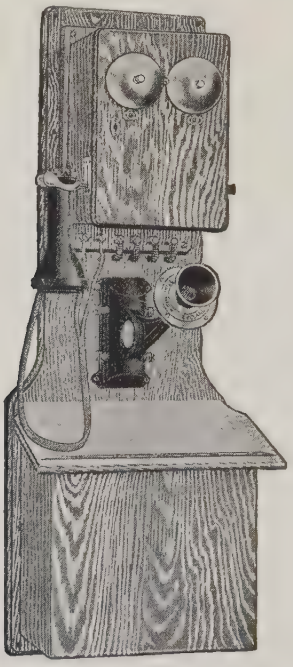


Figure 69.

Figure 69 illustrates a double battery box long distance telephone. In this instrument the two batteries that are used to

operate the transmitter are placed in the battery box, the top of the battery box forming a convenient shelf for writing. This is the most popular type of telephone and is considered the standard.

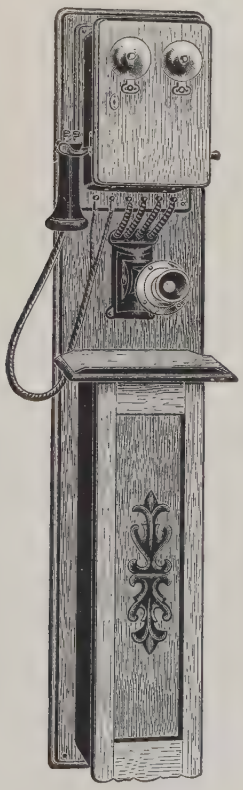


Figure 70.

Figure 70 illustrates a tandem battery box telephone. In this type of telephone the battery box has a partition in it and one battery sets above the other. This is also a popular type.

Figure 71 illustrates a triple battery box telephone. In this telephone the battery box is wide enough for three battery cells, which set side by side. This is the type of telephone usually used on heavy toll lines where very long distances are to be talked over, as three powerful battery cells can be placed within the battery box.

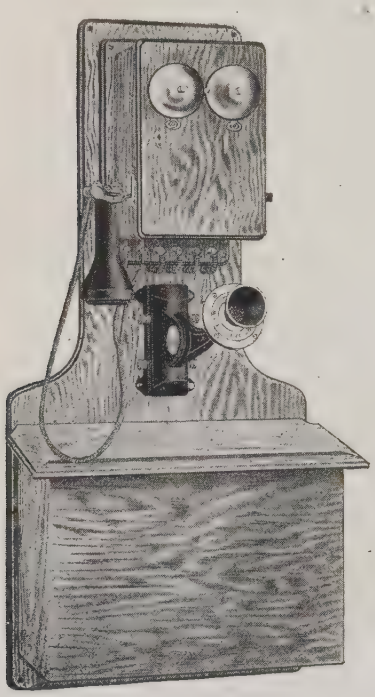


Figure 71.

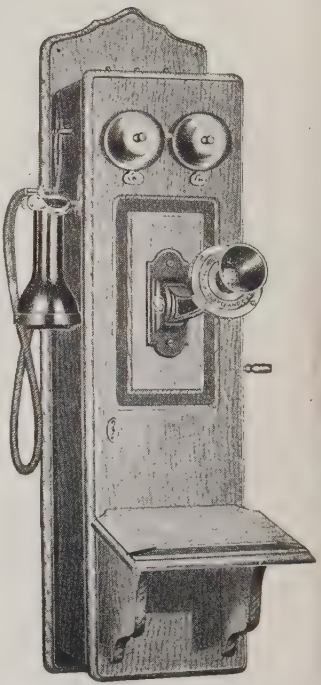


Figure 72.

Figure 72 illustrates a compact, or as it is sometimes called, dry battery telephone. In this telephone the cabinet work forms a box which contains the ringer, the generator, the switch-hook, the induction coil and the two cells of dry batteries necessary to operate it. This forms a very neat and somewhat convenient telephone for an office or any place where room is an object.

Figure 73 illustrates another type of telephone in which the batteries are to be located at any convenient point near the telephone. The microphone is mounted on the cover of the magneto bell box and, therefore, there is no adjustment up and down of

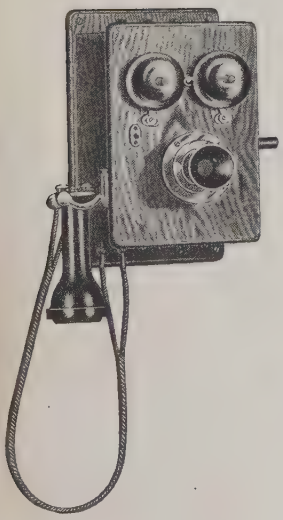


Figure 73.

Figure 74.

the transmitter. This forms a rather compact telephone and is somewhat lower in price than the others on account of not having the amount of cabinet work found in the other types.

Figure 74 illustrates a desk telephone. This type of telephone is a portable set and has a cord on it six feet long which will permit of the telephone being moved around any place that the length of the cord will allow. The ringing apparatus of this telephone comprises a hand boxed generator, which is shown in Figure 75,

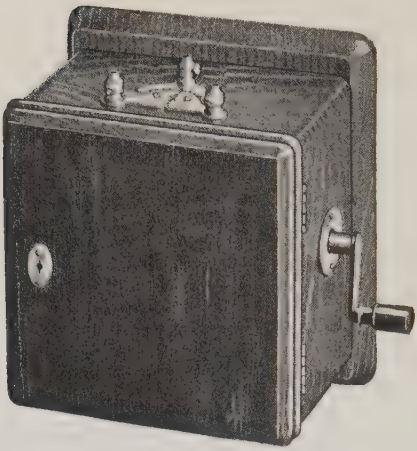


Figure 75.

and an extension bell shown in Figure 76.

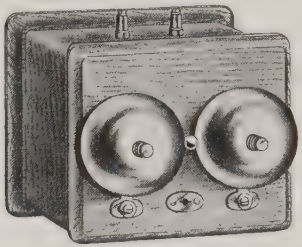


Figure 76.

Figure 77 shows a diagram of the connections in this 'phone The extension bell, hand boxed generator and the circuit shown in the dotted lines, show how a desk telephone is to be connected up and used on a bridging circuit; while the solid lines show how the ringing attachment is to be connected when this telephone is to be used on a series circuit.

The telephones illustrated herewith are a few of the styles of telephones manufactured by The Williams Electric Telephone Company.

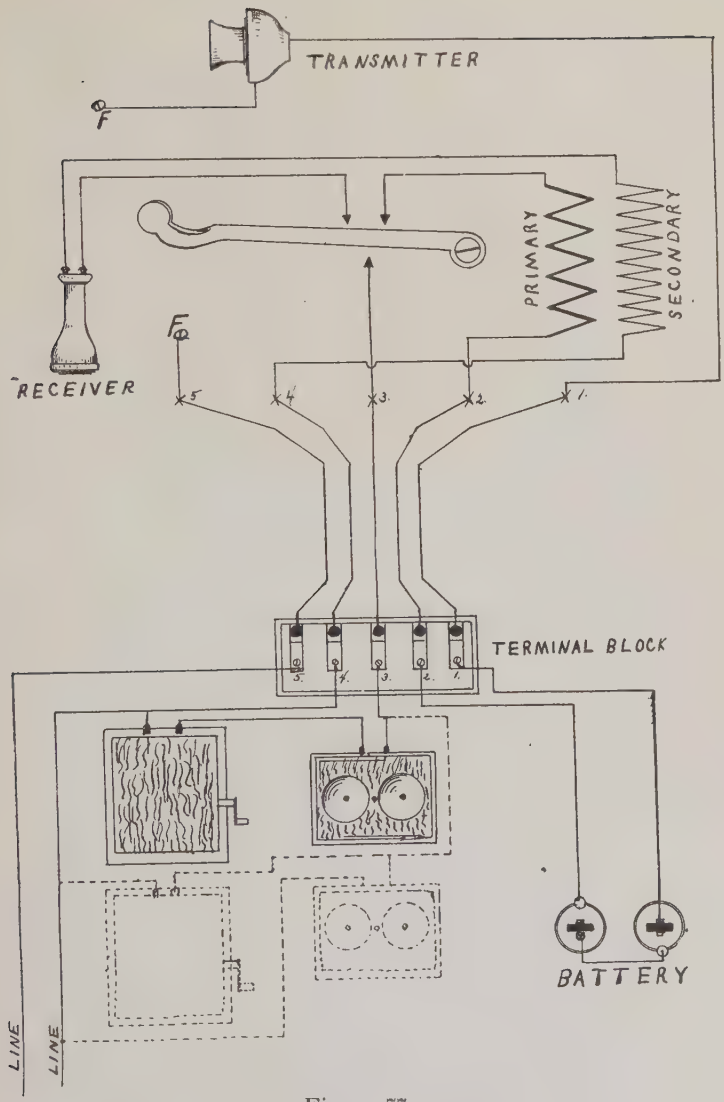

TRANSMITTER
F
PRIMARY
SECONDARY
RECEIVER
F
5
4
3
2
1
TERMINAL BLOCK
BATTERY
LINE
LINE

Figure 77.

CHAPTER X.

LIGHTNING ARRESTERS AND SWITCHES.

In order to protect telephones from discharges of lightning and from heavy discharges of atmospheric electricity, it is customary and usually necessary to intervene between the telephone and the main line some protective device in the nature of a fusible wire and a narrow air gap between the line and the ground. This air gap is formed by two pieces of block carbon, separated by a thin strip of perforated mica.

A single pole carbon fuse lightning arrester is to be used on a ground return circuit. The wire leading from the line connects to the screw on the right hand side of the illustration.

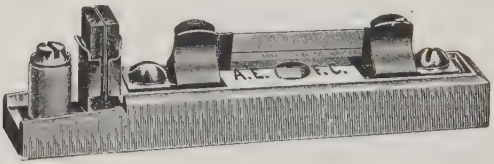


Figure 78.

The wire leading to the telephone connects underneath the screw head that is located between the upright carbon blocks and the fuse clip on the left of the illustration. The ground wire connects under the head of the screw in the extreme left of the illustration. This wire should be run to the same ground rod to which the telephone runs, by being connected on to the ground wire of the telephone.

The action of this lightning arrester is this: if a heavy discharge of lightning comes it will melt the fuse wire, which is pasted to the little piece of mica that shows plainly about the center of the illustration, and would jump the small air gap between the carbon blocks on the left of the illustration and be conducted from there to the ground. After a lightning storm, dust sometimes collects between these carbon blocks; they should be

slipped out and the dust blown off and the mica placed back between them and then reinserted in their position, for should they become short-circuited by carbon dust, they would, of course, short-circuit the line.

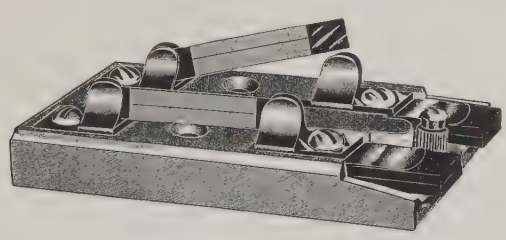


Figure 79.

Figure 79 shows a lightning arrester for metallic circuit use. This metallic circuit lightning arrester is connected just the same for each side of the circuit. The ground wire in this case connects under the screw head that is on the right hand side of the illustration (Figure 79), which connects with the bottom set of carbon blocks as they rest on a brass plate to which the ground wire is attached. The line wires are in contact with the top set of

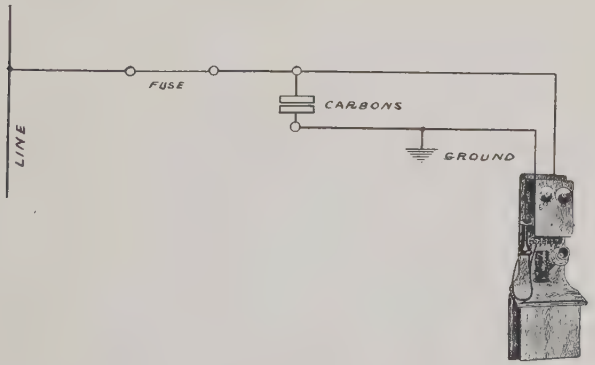


Figure 80.

carbon blocks, and the strip of mica that separates the carbon blocks forms the air gap between the line wires and the ground.

The tendency of the lightning is to jump this small air gap in preference to burning out the windings on the telephone, since the air gap is so thin, offering to the lightning a much easier path than the high resistance windings of the telephone.

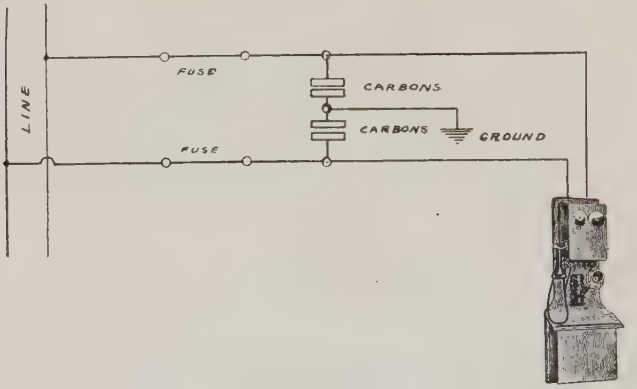


Figure 81.

Figure 80 shows a diagramatic connection of a single pole lightning arrester as properly connecting a telephone to a ground return circuit telephone line.

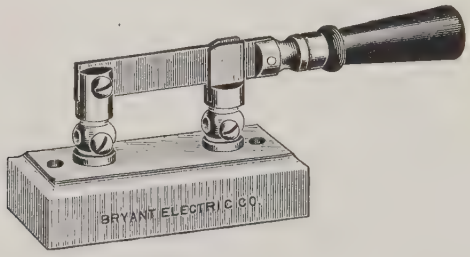


Figure 82.

Figure 81 is a diagramatic illustration of the proper way to connect a telephone to a metallic circuit line by means of a double pole carbon fuse lightning arrester.

BABY KNIFE SWITCHES. Baby knife switches are also used sometimes in place of lightning arresters.

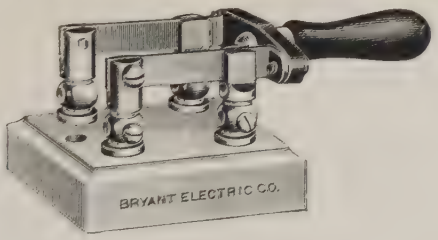


Figure 83.

Figure 82 shows a single pole baby knife switch.

Figure 83 shows a double pole baby knife switch. When these knife switches are used instead of lightning arresters, they are inserted in the line between the telephone and the main line, so that they can be opened during a storm, thus cutting the telephone entirely off the line by breaking the circuit, as shown in Figure 85.

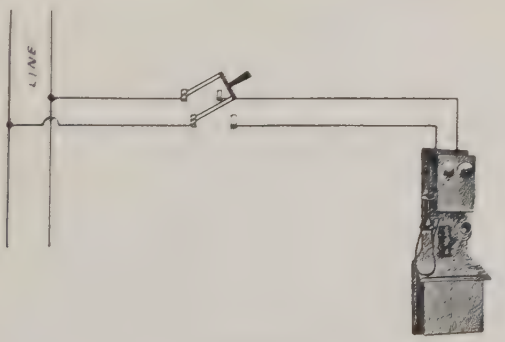


Figure 85.

These baby knife switches can also be used on series telephone lines. When used on a series telephone line they are bridged across the terminals of the telephone so that when they are closed, they shunt the telephone out of circuit, and when the lever is thrown open, of course, the telephone is in the proper position to give service.

CHAPTER XI.

EXTENSION BELLS AND HOUSE BELLS.

When it is desired to have a signal given at some point out of hearing of the regular telephone ringer, an extension bell is used. Extension bells are made for both bridging and series lines. To properly connect a bridging extension bell, simply bridge it across the line binding posts of the telephone and run the two wires back to where the extension bell is to be located. Connect the two wires to the binding posts on the extension bell. An extension bell should be of the same resistance as the ringer of the telephone it is used with.

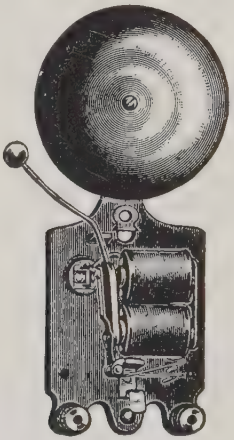


Figure 86.

Series extension bells are to be connected into the ringer circuit of the telephone and are only to be used in conection with series telephones. Where it is desired to send a signal a short distance, such as between a house and barn or from a door to some point in the house, an ordinary vibrating house bell is used.

Figue 86 shows an ordinary house bell. The figure shows the bell with cover removed, exposing the magnets and vibrating armature which carries the hammer.

The bell is operated by means of a push button which is located either on the door frame or at any convenient place from which it is required to send a signal. An open circuit battery furnishes the current for the bell.

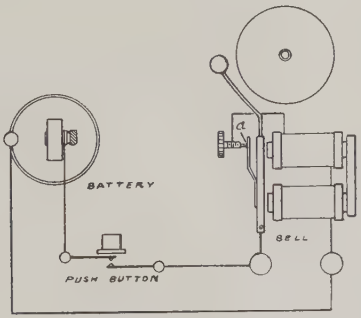


Figure 87.

Figure 87 shows a diagram for wiring and connecting an ordinary house bell. By referring to Figure 87 it will be seen that the battery, bell and push button are all in series. These house bells are also used as night bells on large switchboards, so that when the drop or shutter falls, it closes the circuit very much as a push button would do and rings the bell continuously until the attendant restores the drop shutter to answer the call.

CHAPTER XII.

SWITCHING DEVICES AND SWITCHBOARDS.

When two separate telephone lines end at one point and a party on one line wishes to communicate with a party on the other line, some switching device is necessary to signal the party and to connect the two lines together. It is obvious that the party who is going to make connections must be able to communicate verbally with the subscribers of both lines. Therefore, the operator's station, as we will call it, has to be equipped with a complete telephone.

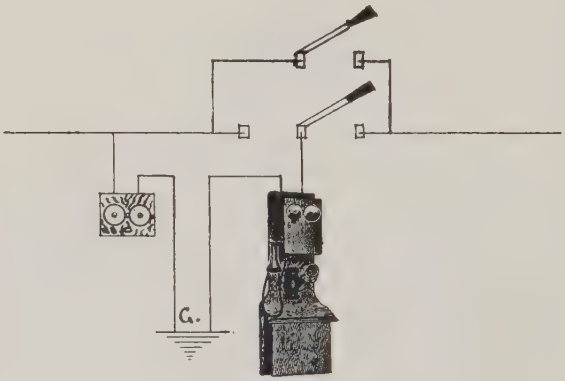


Figure 88.

Figure 88 shows the method of connecting two bridging grounded lines together. The operator's telephone is connected to the blade contact of a single pole double throw baby knife switch. The end of each line is connected to the end contacts of this knife switch. An extension bell is connected on one of the lines and the telephone is intended to be left connected normally to the other line. When the operator receives a call on one line, he will swing his switch over to the line with which connection is

wanted and ringing up the desired subscriber, closes the upper single pole single throw baby knife switch, thus joining the two lines together.

It will be noticed that the telephone can ring on either line separately without disturbing the other line and that by closing his switch he can listen in on either or both lines, or can talk to either or both lines at one time. As soon as the subscribers are through talking, either one of them can give the ring-off signal which, of course, will be heard by the operator. Then he can open the upper switch, thus separating the two lines. The extension bell and operator's telephone are both connected to the same ground rod.

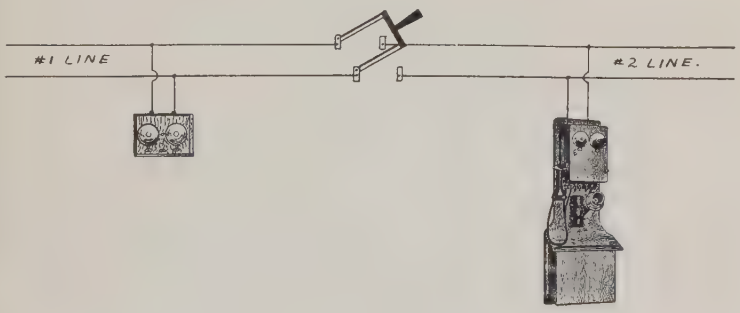


Figure 89.

Figure 89 shows the method of connecting two bridging metallic circuit lines. A double pole knife switch is used in this case, instead of a single pole, there being two lines to be connected and disconnected by the switch. This principle is just the same as in Figure 88, only there is no knife switch shown on line No. 2, although there ought to be a knife switch between No. 2 and the operator's telephone, permitting the operator to disconnect his telephone from line No. 2 when sending out a call over line No. 1. This is the fundamental principle of all telephone switchboards, that is, of switching one line onto another.

Figure 90 shows the method of connecting three bridging lines together or of connecting any two of the three lines. The switch to which the telephone is connected, marked No. 2, can be thrown either onto line No. 2 or line No. 1, and the parties called

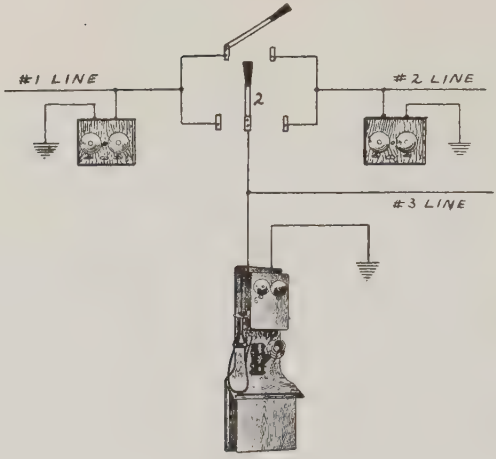


Figure 90.

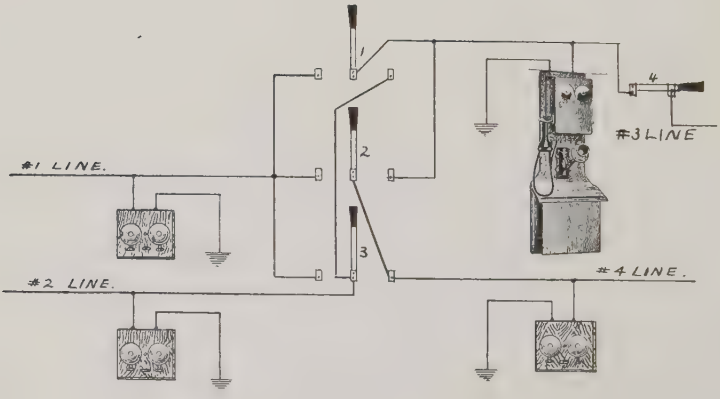


Figure 91.

up; and if No. 1 line wants connections onto No. 2, he will merely close the top switch, which is a single pole knife switch. This, of course, connects the two lines together and the operator can remain connected with them himself if he desires; and, if not, the extension bells will give the signal to disconnect. There is no switch shown to open line No. 3 in the diagram, but it is best to use a switch also on line No. 3, so that line No. 3 can be cut off from the operator's telephone when he is calling on either of the other lines and not disturb the subscribers of line No. 3 by ringing their bells when unnecessary.

Figure 91 shows a method of connecting four lines by means of three single pole double throw knife switches and one single pole single throw knife switch that is connected on line No. 4, so as to cut off the operator's telephone when ringing on the other lines. Should line No. 1 want connection with line No. 2, the call is received on the extension bell connected with line No. 1. The operator opens switch No. 4 on line No. 3 and throws switches No. 1 to the left and ascertains what subscriber is wanted.

If subscriber on No. 1 should want to talk to No. 2, he throws switch No. 1 to the right, calls up subscriber on No. 2, then throws No. 3 switch to the left which connects line No. 1 with line No. 2. If line No. 1 should want line No. 3 instead of No. 2, he would simply raise and throw switch No. 1 to the left, and close switch No. 4. If line No. 1 should want line No. 4, he would simply throw switch No. 2 to the left.

By following out the connections, it will be easily seen that any one line can talk to any other line individually, or either one of the other two lines and the operator can listen or not, as is seen fit.

Where more connections than four lines are wanted, it is best to use a different arrangement of wiring so as to keep the system of connections simple.

Figure 92 shows six grounded bridging lines running into a common center and means for connectig them with single pole single throw knife switches. The knife switches in this illustration are shown with the blades open and the reader is looking down upon the rubber handles of the switches, hence the black dots under the figures 1, 2, 3, 4, 5, 6 represent the switch handles that are on the end of the switch blades. Here line No. 1 con-

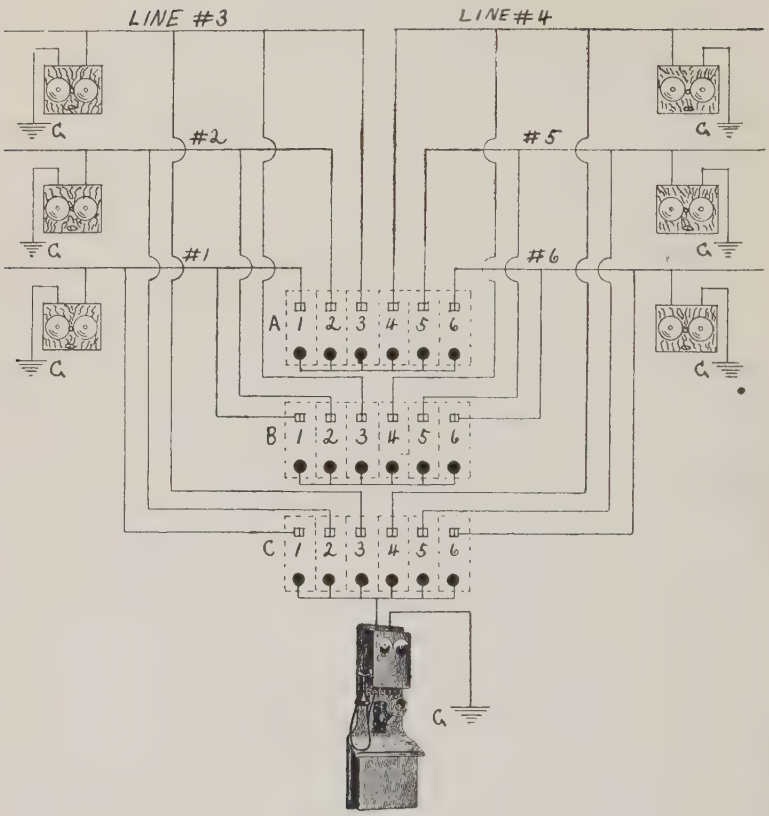


Figure 92.

nects with the upper terminal of the three switches marked No. 1 and line No. 2 connects with the upper terminal of the three switches marked No. 2 and so on. The blade part of the switches of each group are connected all together and the operator's telephone is connected to the blade part of the lower group of switches.

Each line is provided with an extension bell so that the operator can receive an incoming call. Should line No. 1 ring in, the operator will recognize line No. 1 by the signal, as all of

the different lines will have different signals. For instance, line No. 1, one long ring; line No. 2, two long rings; line No. 3, three long rings; line No. 4, one short ring; line No. 5, two short rings; line No. 6, three short rings, or any code of signals that is agreed upon. Upon receiving one long ring, the operator will immediately close the switch marked No. 1 of the lower group and ascertain what subscriber on which line is wanted. Say line No. 5 should be wanted, he will immediately open switch No. 1 and close switch No. 5 in the lower group, and so ring up the party wanted on line No. 5. He will then close switch No. 1 and No. 5 in either one of the other two groups and the parties are connected. Each group of switches represents a pair of plugs and a cord in an ordinary switchboard. Hence, it will be seen that but two telephone lines can be connected together on one group at one time, and two other telephone lines can be connected together on the other group of switches at the same time, so that any four lines out of the six can be in use at the same time on this switchboard and will all work independently of each other, and should the operator wish to use his own, the lower group of switches, he could also connect the other two lines by means of two switches on that group, so that all six lines can be connected into three at the same time.

One advantageous feature of switchboards of this type is that they are comparatively inexpensive and that the material of which they are made, knife switches and extension bells, are standard articles and are not susceptible to wear, like the delicate parts of an ordinary switchboard.

Should all of the switches of any one group be closed, then all of the six lines would be connected together at one common point and the operator could talk to all of the subscribers on all of the lines. Such cases of this kind are very convenient for giving election returns or any other general news to the entire community at one time.

The average cost of switchboards of the above type is for the 18 knife switches, at 25 cents each, $4.50. This being the only cost excepting the cost of the extension bells which, of course, will depend upon the resistance to which they are wound. Each one of them should be of the same resistance as are the bridging telephones connected on to the line to which it belongs.

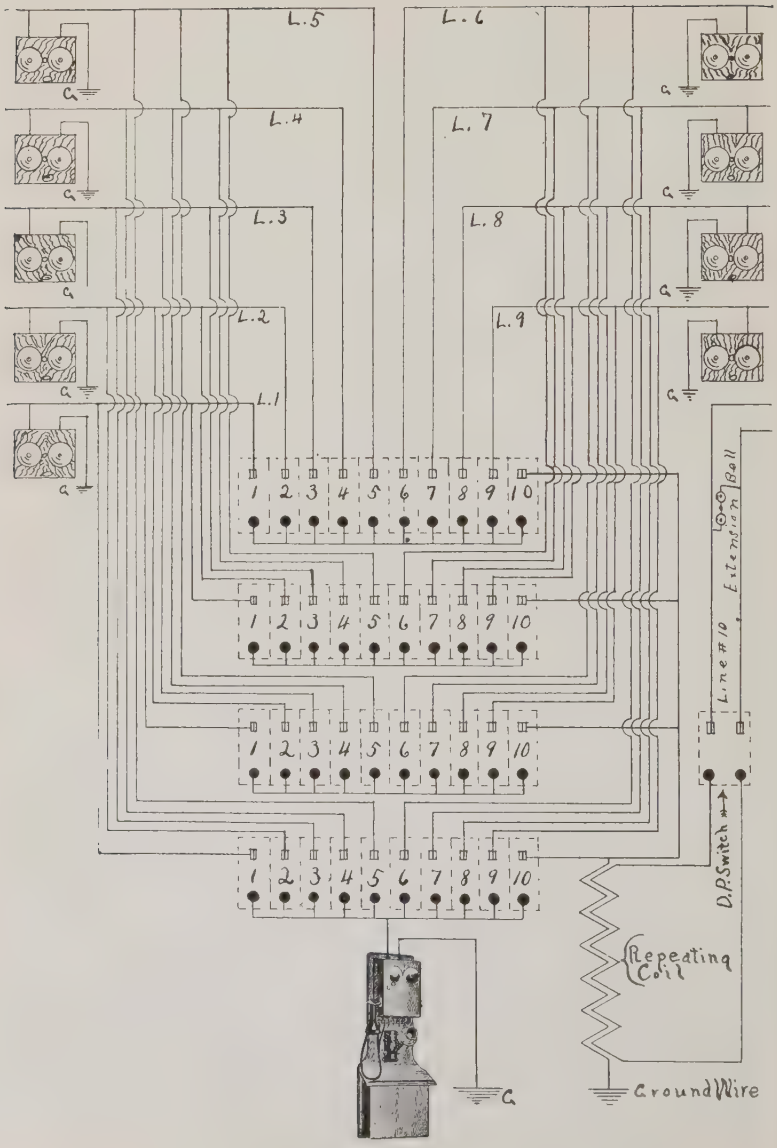

L.5
L.6
L.4
L.7
L.3
L.8
L.2
L.9
L.1
1 2 3 4 5 6 7 8 9 10
1 2 3 4 5 6 7 8 9 10
1 2 3 4 5 6 7 8 9 10
1 2 3 4 5 6 7 8 9 10
Line #10
Extension Bell
D.P. Switch
Repeating Coil
Ground Wire
G

Figure 93.

The lines marked "G" represent ground connections. Of course one ground connection can be run to all of these instruments, although for the sake of simplicity in the diagram, each extension bell is shown to have a separate ground connection.

Figure 93 shows a switchboard of the same type exactly as the figure just mentioned, but this diagram is shown wired up for nine grounded bridging lines and one metallic circuit line. The metallic circuit line comes into the switchboard through a repeating coil, which is shown in the lower right hand corner of the diagram. It will be noted that one end of this repeating coil connects with the top terminal of all of the switches marked "No. 10," or in other words, one side of this repeating coil is connected on to the switchboard just like any other of the grounded lines. The metallic circuit side, of the repeating coil, passes through a double pole single throw baby knife switch, which is left open except when the metallic circuit is in use. A diagramatic view of an extension bell is shown bridged across the metallic circuit, so as to receive an incoming call on the metallic circuit.

Suppose line No. 3 would ring into the switchboard, the operator would close switch No. 3 on the lower group of switches and ask the subscriber on No. 3 whom he wants; suppose he should ask for some subscriber on the metallic circuit line or line No. 10, he would open switch No. 3, close switch No. 10 and close the double pole switch in the metallic circuit, turn the crank on the telephone, giving the necessary signal to the subscriber wanted on the metallic circuit line. Then he would close switch No. 10 and switch No. 3 in either one of the three upper groups that happen to be idle. Then the two lines would be in service.

In actual practice it is found that a repeating coil which makes a first class talking coil will not make a good ringing coil. Therefore, it is generally better to ring direct on the metallic circuit, which could be done in this diagram by having an ordinary bridging generator bridged across the metallic circuit line near the extension bell; that is, between the extension bell and the double pole knife switch; and when signalling on the metallic circuit, this knife switch should be open so that none of the ringing current would go back and be wasted through the repeating coil. This bridging generator, of course, should be equipped

with an automatic cut-in so as to not be bridged across the line except when in the act of sending out the signal.

The connections and operations on this switchboard are identically the same as those shown in Figure 92, except that this switchboard is made for ten lines and has four groups of switches which, of course, would allow eight lines to be in use at one time, provided the operator used each group of switches for connecting two of the lines.

The cost of this switchboard, outside of the extension bells, would be the 40 baby knife switches at 25 cents each, which would be $10.00, and if a metallic circuit line is used instead of a grounded line, for one of the lines, of course a repeating coil would have to be cut in on the metallic circuit line. These switches can be mounted on any convenient board, as they do not occupy much space and all connections and wiring can be open to view, so that it can be easily inspected. This makes a first class plan for making an inexpensive but good switchboard for small rural exchanges.

PARTY LINE SIGNALS. Figure 94 shows a code of signals, which are arranged very conveniently for party line work. It is made up of long and short rings. The long rings constitute about three complete turns of the crank. The short rings constitute but one turn of the crank. It will be noticed by referring to the illustration that six signals for six different telephones can be made by using only two rings; fourteen separate signals can be gotten with only three rings; that twenty-six signals can be gotten with only four rings, and that fifty signals can be gotten with only five rings.

The author would suggest on switchboard signals that each line give its proper number. For instance: Line No. 1, give one long ring; line No. 2, two long rings; line No. 5, five long rings, and line No. 6, one short ring; line No. 8 would be three short rings and line No. 10, five short rings. This enables the switchboard operator to know whether or not the switchboard is wanted and will also show just exactly which line has called in.

Referring to the six and ten line switchboards in Figure 92 and Figure 93, the horizontal lines that the extension bells are bridged onto, of course, represent the line wires. These lines extend on out into the community and have different numbers of

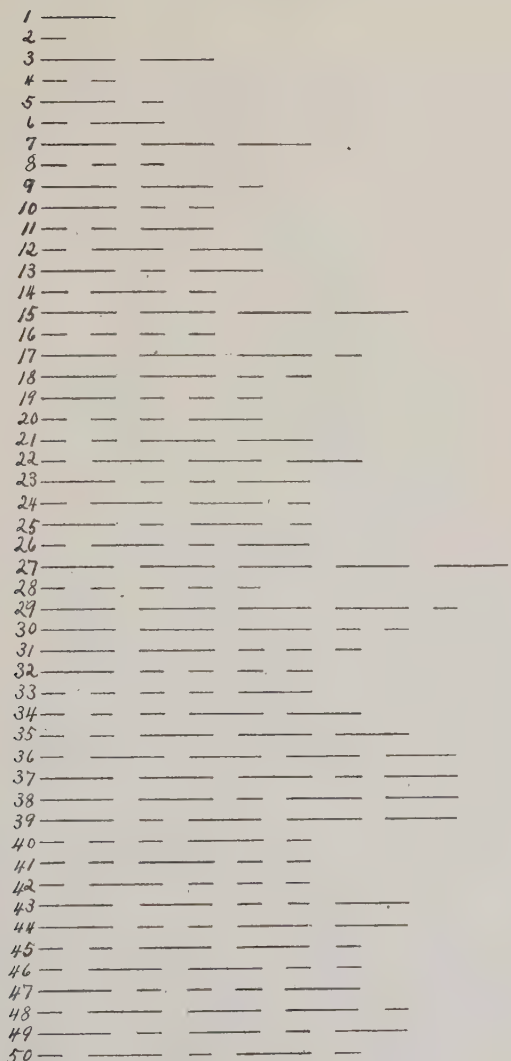


Figure 94.

telephones bridged on according to the number of subscribers which they accommodate.

In regular switchboards, as manufactured by the different telephone manufacturers, drops which have shutters on them are used to receive the signal, and spring jacks, into which are inserted plugs that are connected together with flexible cords, are used to connect the lines together.

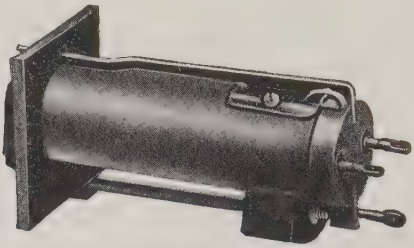


Figure 95.

Figure 95 shows a complete high wound tubular bridging drop with relay attachment. This relay attachment has two platinum contacts, one of them on the armature and the other one held on an insulated rubber block; when a signal comes in the armature closes these two contacts intermittently, counting off the different signals that the line sends in by giving rings on the night bell. These contact points occupy the same position in the night bell circuit that a push button does in the house bell circuit illustrated in Figure 87. All switchboards are not equipped with this relay attachment. When they are not equipped with the relay attachment, it is necessary for the operator to be near the board in order to see what shutter falls; also near enough to hear the slight rattle that the armature of the drop makes, so that he can tell whether the subscribers are merely calling up each other on the line or whether the switchboard is wanted.

Night bells are also used on some switchboards so as to notify the operator that some drop has fallen. They operate by the drop falling and permanently closing the night bell circuit, which keeps the night bell ringing until the shutter is restored to its normal position.

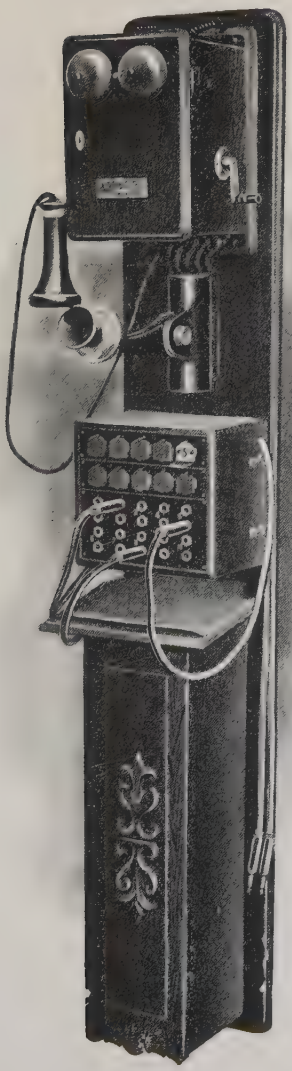


Figure 96.

Figure 96 shows a ten line Farmers' Community Switchboard with ten drops, with one shutter down. On this particular type of Farmers' Community Switchboard there are no cams or levers to operate, but there are two jacks for every drop, and the switchboard comprises a complete telephone, as well as the switching apparatus. The operator does the calling by means of an operator's plug. This plug is connected to the two line binding posts of the telephone, on the top of the magneto bell box, and there are two jacks for every drop. In explaining the circuits of this board, we refer the reader to Figures 97 to 99 inclusive.

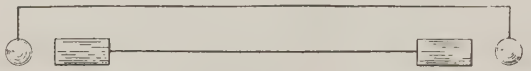


Figure 97.

Figure 97 shows diagramatically a cord and two plugs. Every plug has a ball and sleeve, the ball being on the end of the plug and the sleeve part next to the handle. The cord which is, of course, a metallic circuit or double wire cord, connects with one wire the two sleeves, and with the other wire the two balls of the plugs that are on each end of the cord.

Figure 98.

Figure 98 shows one line connected with the two jacks and one drop. One jack, the upper one, we will call the answering jack. The lower one we will call the calling jack. The drop is shown, bridged across the line from the calling jack, so that when a plug is inserted in the calling jack, it lifts up the jack spring, thus opening the circuit of the drop; consequently, when ringing out on the line, the drop will not fall.

Figure 99 shows two lines connected together, line No. 2 and line No. 3. It will be seen that one plug is placed in the calling jack of one line, and the other plug, which is on the opposite

end of the cord, is placed in the answering jack of the other line, so as to leave but one drop bridged across the two lines to receive the ring off signal when they are through talking. It will be noticed that the sleeve of the plug fits snugly into, and gets connection on the frame work of the jack, and the ball or extreme end of the plug gets connection on the springs in the jack.

Suppose that a signal were to come in on line No. 2, the operator would insert his operator's plug into the answering jack of line No. 2, ascertain what subscriber is wanted; then he should withdraw his plug from line No. 2, insert it in the calling jack of the line that is wanted, give the necessary signal to call the sub-

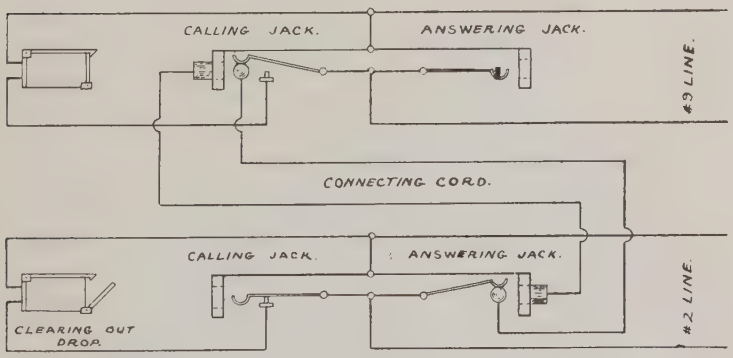


Figure 99.

scriber, then pick up a pair of plugs, belonging, of course, to one cord; insert one plug in the answering jack of one of the lines and the corresponding plug in the calling jack of the other line. The two lines will then be in communication with each other.

This system of wiring is very simple and substantial and has given excellent service for small switchboards; switchboards of a capacity up to 25 drops.

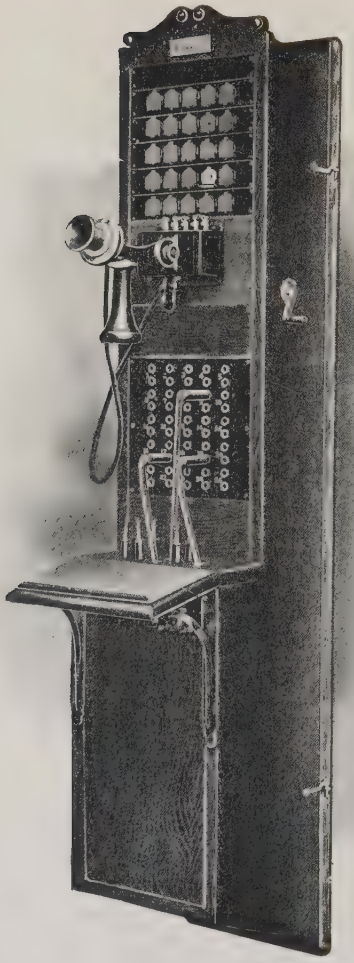


Figure 100.

Figure 100 shows a type of Farmers' Community Switchboard for 25 lines, which is wired on the system just described.

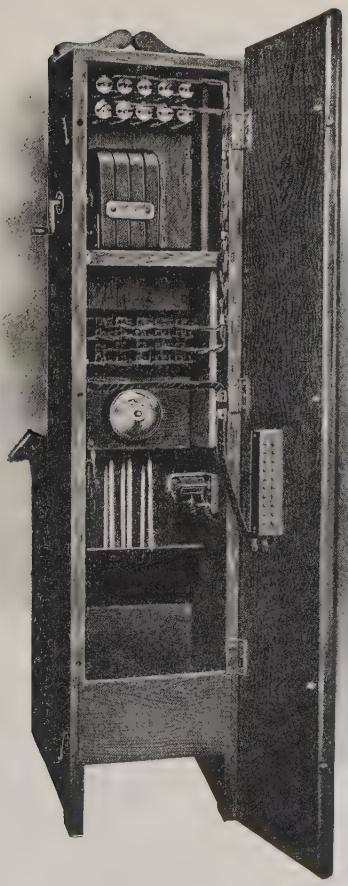


Figure 101.

Figure 101 shows the back of a ten line Farmers' Community Switchboard which has the same type of cabinetwork as the 25 line switchboard. The tubular drops are shown in the top of the illustration and the calling and answering jacks underneath the calling generator. The wiring, connecting the jacks and the drops to the different line terminals is in the cable running down

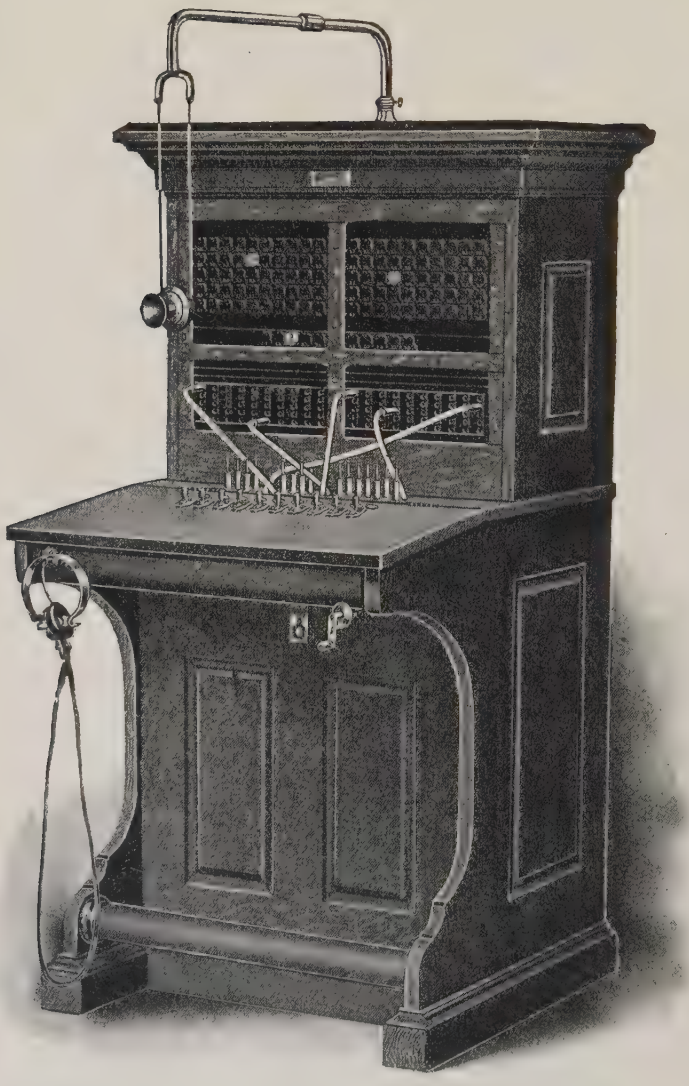


Figure 102.

the right hand edge of the switchboard to a terminal block that is on the inside of the door of the switchboard.

Underneath the jacks is shown the night bell, which may also be used in the relay circuit, if the switchboard is a relay board. An ordinary telephone ringer, but without any gongs, is shown underneath the night bell. This telephone ringer is a low wound ringer, of about 80 Ohms resistance, and is connected in series with the generator, so that in sending out calls, it forms an audible means of hearing the signal that is being sent out.

Most people, unacquainted with the technical side of the telephone business, have an idea that the circuits of a switchboard are very complicated and hard to understand, but such is not the case at all; if all of the different parts of a switchboard are taken into consideration and the functions which they perform are well known, it becomes an easy matter to trace the circuits. All switchboards operate on about the same principle.

Figure 102 shows a 100 drop switchboard of the ordinary type. In this switchboard, there are ten pairs of plugs and cords, and the operator instead of having an operator's plug, as is done with smaller boards, uses ringing and listening cams, which are shown in front of the row of plugs. These ringing and listening cams are nothing but levers, which have spring contacts that throw the operator's talking and listening circuit onto the pair of plugs that are opposite them, and they also throw the switchboard generator on to either one of the plugs, so that she can ring them up. The only function of these cams is that of the operator's plug on the smaller switchboards.

REPEATING COILS.

Figure 103 shows the proper method of connecting a repeating coil to any switchboard, using drops and jacks. In the diagram, a metallic circuit line is shown connected to a grounded circuit line through the medium of a repeating coil. This is a diagramatic illustration just to show the principle. The two wires, connecting with one plug or a pair of plugs, are connected to the terminals of one coil of the repeating coil; and the other plug belonging to the same pair is connected onto the terminals of the other coil of the repeating coil. This one pair of plugs, which are connected together through means of the repeating coil, can, of course, be used to connect any of the lines on the

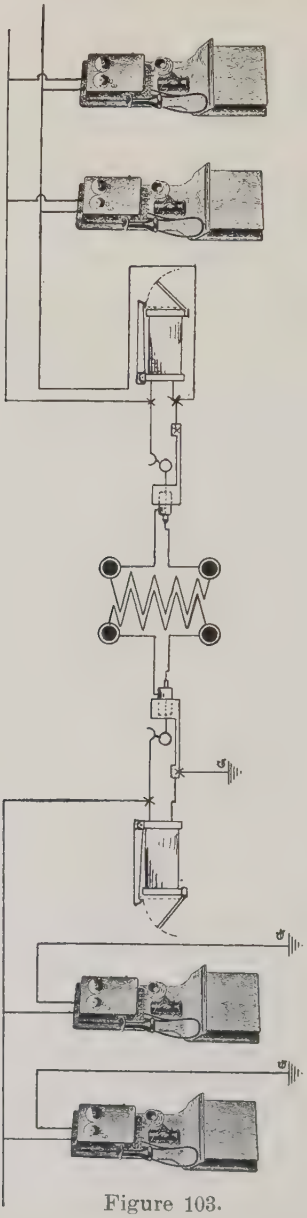


Figure 103.

switchboard, although on switchboards using cams and levers for calling, ringing and listening, it is better to ring up parties with an ordinary pair of plugs, so as not to complicate the connections in the repeating coil. Then when the parties are ready for connection, withdraw the ordinary plugs and insert the plugs that are connected with the repeating coil.

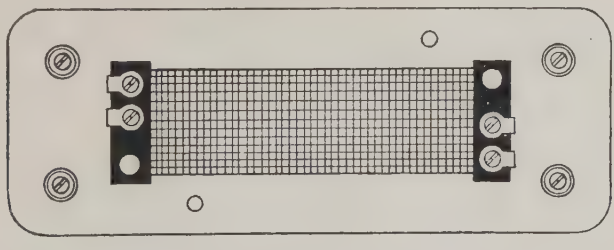


Figure 104.

Figure 104 shows an improved form of repeating coil that is manufactured by the Williams Electric Telephone Co. This repeating coil has a talking efficiency of 95 per cent, but cannot be used to transmitting ringing currents, as it is constructed on the open magnetic circuit plan, and is especially designed for the rapidly vibratory talking current. These coils are constructed on a regular induction coil frame and ordinarily the coils are wound to a resistance of 250 Ohms each. This is a much better type of coil to use for talking purposes than the old style, or closed circuit form, of repeating coil; for the closed circuit form of repeating coil, only has a ringing efficiency of about 25 per cent and a talking efficiency of but 10 per cent, making it but a poor device to transmit ringing currents, and an extremely poor device for transmitting talking currents. The repeating coil above illustrated will not transmit ringing currents at all, but, as above mentioned, will transmit talking currents with but such a slight loss as not to be noticeable.

The author, therefore, does not recommend repeating coils for transmitting ringing signals, but that an open magnetic circuit coil of the above type be used for transmitting talking current from grounded to metallic circuit lines or vice versa. As repeating coils are always located at the switchboard, it is no trouble to ring direct and then connect in the repeating coil by means of cords and plugs and talk through the repeating coil.

CHAPTER XIII.

MEANINGS OF A FEW OF THE MOST ORDINARY ELECTRICAL TERMS AND PHRASES APPLIED TO TELEPHONY.

AMPERE: the unit of current volume.

ALTERNATING CURRENT: a current which alternates in direction; that is, the positive and negative poles are being constantly reversed or alternated.

BINDING POST: a metal post for connecting two or more wires.

CIRCUIT: a complete path which an electrical current takes in going from the positive to the negative pole of its source.

CAPACITY: the property of a circuit or condenser which enables it to transfer current from one side of the circuit to the other through an insulating medium.

CARBON BACK PLATE: the part of a microphone which contains the globular or granular carbon, and is located back of the diaphragm.

CONDUCTOR: a wire or any material that will allow electricity to pass through it.

DIRECT CURRENT: a current that flows always in one direction.

DIELECTRIC: any substance which permits electrical induction to take place through it; invariably an isulating material.

DIAPHRAGM: a thin disc of any size and of any material. A receiver diaphragm is always of iron and a transmitter diaphragm usually of carbon.

EXTERNAL RESISTANCE: the resistance outside of a generator, battery or a piece of electrical apparatus; usually meaning the line resistance.

ELECTRODE: either the positive or negative element of a battery; spoken of as the positive or negative electrode.

ELECTRO MAGNET: an iron core surounded with a

winding of insulated wire which retains magnetism only when current is flowing through the winding of the coil.

GENERATOR: that part of a magneto bell that is operated by turning the crank, and which generates electricity to operate the ringers.

GROUNDED CIRCUIT: a circuit using the ground as part of its return path.

INTERNAL RESISTANCE: meaning the resistance within a piece of apparatus; thus the internal resistance of a ringer is its resistance; or the internal resistance of a cell of battery is its own resistance.

INDUCTIVE RESISTANCE: that resistance offered to the starting of an electrical current through a circuit due to the self-inductance of the circuit.

INDUCTION: the influence exerted by a charged body or by a magnetic field on neighboring bodies without apparent communication; also the influence produced through a dielectric by the action of an electro-static or magnetic flux.

INSULATOR: a device to electrically insulate an electrical conductor to prevent the leakage or passage of current from the conductor at that point.

INDUCTION COIL: that part of a transmitter which raises the Voltage of the primary current and magnifies its vibrations by alternating them.

LIGHTNING ARRESTER: a device for protecting telephones or other electrical apparatus from lightning.

LINE RESISTANCE: the resistance of the line wire; if a ground return circuit, meaning the resistance of the line wire from one end of the line wire to the other; if a metallic circuit line, the resistance of both sides of the metallic circuit.

METALLIC CIRCUIT: a circuit composed of metal or wires throughout its entire course.

MULTIPLE CIRCUIT: a circuit in which the current divides pro rata to the resistance among the different pieces of apparatus bridged across it.

MICRO-FARAD: the unit of capacity.

MEGOHM: one million Ohms.

MILLI-AMPERE: one one-thousandth of an Ampere.

MAGNETIZATION: the act of imparting or acquiring magnetism.

MICROPHONE: that part of a transmitter into which we talk (sometimes called transmitter head.)

NEGATIVE POLE: that part of a battery at which the current returns to the battery from the circuit.

OHMIC RESISTANCE: meaning resistance due to Ohms of resistance in contradistinction to inductive resistance.

OHM: the unit of resistance.

OPEN CIRCUIT: a circuit that is broken or disconnected.

POLARITY: of which pole of a permanent magnet the article polarized partakes; as in north or south polarity.

PERMANENT MAGNET: a hardened steel bar of any shape, which retains magnetism all of the time.

POLARIZE: to polarize a magnet (refer to polarity); also a term to denote that hydrogen gas collects on the positive electrode of a cell of battery (a battery becomes polarized when clogged up by hydrogen gas.)

POSITIVE POLE: that pole of a battery from which the current leaves the battery.

PRIMARY COIL: the heavy and inner winding of an induction coil.

PRIMARY CIRCUIT: that circuit of a telephone which includes the battery, the microphone, the primary coil and contact points for opening and closing the primary circuit.

RINGER: that part of a telephone which goes on the inside of the cover of the magneto bell box or telephone cabinet, and receives the ring or signal.

RECEIVER: the ear 'phone or instrument which receives the conversation.

REPEATING COIL: two coils of wire of the same resistance that are wound around a soft iron wire core and used to repeat from a grounded to a metallic circuit.

SERIES CIRCUIT: a circuit which includes every piece of apparatus connected in one circuit passing the same volume of current throughout the circuit.

SATURATED SOLUTION: a solution in which no more of the material to be dissolved can be dissolved.

SHUNT: a by-path formed of a conductor of any desired resistance to allow some or all of the current to pass by instead of through the device shunted.

SHORT CIRCUIT: to make a connection of low resistance; usually where not wanted between the two sides of a circuit.

SECONDARY COIL: the outer and finer wire winding of an induction coil.

SECONDARY CIRCUIT: that circuit which includes the secondary coil, the receiver and contact points which shunt or open the secondary circuit and place or remove the terminals of the secondary circuit to or from the line.

SWITCH-HOOK: that part of a telephone on which the receiver hangs and which, by removing or replacing the receiver, operates or switches the different circuits of a telephone.

TRANSMITTER: Usually meaning the microphone, the induction coil and the supporting arm and base; thus, a long arm transmitter.

VIBRATORY CURRENT: an electrical current that varies in strength but does not necessarily vary in direction. Vibratory current can be either alternating or direct.

VOLT: the unit of electrical pressure.

CHAPTER XIV.

LOCATING AND REMEDYING ORDINARY TROUBLES THAT MAY OCCUR IN TELEPHONES.

TROUBLE: a telephone can receive a call but cannot send out a call.

CAUSE: the trouble is either in the generator, automatic cut-in or the wires leading from the generator to the line wires.

REMEDY: disconnect generator and short-circuit it. Turn the crank and see if it generates current, which will be noticed by the crank turning a great deal harder when it is short-circuited than when it is not. If the generator is found to generate all right, examine automatic cut-in to see if it operates properly. If it operates properly and still no current can get to the line, the trouble must be in the wiring or connections between the generator and line.

TROUBLE: can send out a call but cannot receive one.

CAUSE: in this case the trouble must be either in the ringer or the wiring connecting the ringer to the circuit.

REMEDY: examine adjustment of the ringer; see that the vibrating armature is not clogged by dirt or dust between the armature and the core ends; see that the armature can vibrate freely. The armature should slam itself gently, either on one side or the other, and stick to one side or the other, which will show that there is magnetism in the permanent magnet. The permanent magnet can be tested for magnetism with an iron key, or any convenient piece of iron. The magnetism should be very strong in the ringer magnet. If there is no magnetism at all in the ringer magnet, the ringer will not operate. Examine the windings of the ringer to see that none of the leading out wires are broken. Examine all connections carefully and if the ringer is all right and it still will not operate, the trouble must be in the connections between the ringer and the line.

TROUBLE: telephone sends out and receives a ring weakly.

REMEDY: if on a grounded circuit examine ground con-

nection. See that it is amply deep below the frost or drouth line and that the wire connecting with the ground rod is not broken. If the telephone, in question, is the only one on the line that sends out and receives a ring weakly and all connections are found to be properly made; then the generator is weak in magnetism and the ringer is probably higher wound than are the other ringers on the line, or it would receive a ring with the same vigor that the others do.

TROUBLE: batteries wear out very rapidly.

REMEDY: See that the subscriber does not leave his receiver off the hook when telephone is not in use. Examine hook connections to see that the battery circuit is positively opened when the receiver is hung up; or that the receiver is sufficiently heavy, or the lifting spring of the hook is sufficiently weak to surely allow the hook to go down as far as it should go every time the receiver is hung on it. Examine the binding posts on the transmitter base to see that there is no short-circuit in the transmitter base that would shunt out the microphone, thus making a very low resistance in the primary circuit.

TROUBLE: can talk out nicely and be heard well, but can not hear well.

REMEDY: the trouble in this case is in the receiver. Unscrew the cap by turning to the left, take off the diaphragm and see that there is no dirt or dust collected between the diaphragm and receiver core tips. The magnet in the receiver must be strong; sufficiently strong in a good receiver to raise three or four pounds of weight by magnetic attraction, on a smooth piece of soft iron applied to both core tips. Replace diaphragm, screw on cap firmly, tap diaphragm slightly with the finger nail; see if it has a hollow sound, showing that it does not touch the core tips. If it sounds solid or feels as though it touches the core tips, change the adjustment of the receiver so as to clear the diaphragm. All properly made receivers can be adjusted.

TROUBLE: hear faintly, but with a rattling sound.

REMEDY: in this case there is almost surely to be particles of dust between the receiver diaphragm and core tips, which makes the receiver diaphragm chatter. The remedy is as above explained.

TROUBLE: can hear very nicely, but cannot be heard well.

REMEDY: The cause may be weak batteries. Examine batteries. See that they are in good condition or try a new set of batteries that are known to be in first class condition. If this does not remedy the trouble, then the trouble may be the microphone, although troubles with good microphones are very rare. If the microphone is all right, the trouble may be in a partial short-circuit of either the primary or secondary windings of the induction coil. If the trouble is not in the battery, but in the induction coil or microphone, the fault must be the manufacturers and the transmitter should be returned to them for replacement by a new one. If induction coils are properly made, they rarely ever become defective by usage.

TROUBLE: telephone keeps cutting out; can hear parts of conversation and then a break comes, and can hear again after a while, but when can hear at all, can hear well.

REMEDY: this is caused by a loose connection either in the line wires leading to or from the telephone; by a broken conductor in the receiver cord; by a loose connection where the receiver cord is attached to the receiver, or to the magneto bell; or it may be loose connections on the binding posts where the secondary circuit enters the magneto bell. Trouble of this kind is invariably from loose connections in the secondary or line circuit. The only thing is to look for it until found. The placing of a new and perfect receiver cord will demonstrate either that the trouble is or is not in the receiver cord. The conductor of receiver cords will in time become broken so that they open circuit occasionally.

TROUBLE: no telephones on the line can ring or be rung.

REMEDY: if grounded bridging, there is a dead short circuit between the line and ground. If metallic bridging, there is a dead short circuit between the two sides of the circuit. If a series line, the line wire is open at some point either on the line wire itself or by a loose connection in one or more telephones. Remove short circuit.

TROUBLE: all telephones on the line ring and talk weakly.

REMEDY: there is probably a partial short circuit on the line due to a heavy leak, such as carbon dust collecting between the carbon blocks of the lightning arrester or the line wire touching wet wood or foliage. Examine carefully for this point. Perhaps some subscriber has bridged across the line some instrument of much lower resistance than are the telephone ringers. If the trouble occurs in extremely dry or extremely cold weather and the line is a grounded line, perhaps the ground connections are not sufficiently deep to be below the drought or frost line, as dry or frozen ground is a very poor conductor. All ground connections should be made below the point where drouth or freezing would interefere with them.

TROUBLE: the middle telephones or the telephones nearest the center of the line ring and receive stronger than the end telephones or those nearest the end of the line.

REMEDY: the line is probably overloaded for the resistance of the ringer that is used. The remedy is to use a higher resistance ringer that will cause a more equal distribution of current among the ringers along the line. This is a matter that is very easily remedied, as any manufacturer of high grade telephones will readily exchange higher wound ringers for low wound ringers at a nominal charge, as it is to his interest as well as to the subscriber's to see his apparatus give satisfactory service.

CHAPTER XV.

CONCLUSION.

A FEW GENERAL HINTS FROM THE AUTHOR.

Receiver diaphragms should not be dented, buckled or kinked, but should be perfectly flat and true. The transmitter diaphragm, if of carbon, must not be cracked, or poked at with a pencil, and thereby broken. If of metal, they should not be dented or bent. Carbon diaphragms pure and simple are always best, as all metal diaphragms have to have a carbon button in some form riveted on them, because it is a very hard matter to get a good connection between this small thin carbon button that is mounted on the metal diaphragm. It is always best to use a carbon diaphragm straight out and out, and a transmitter of such construction that the carbon diaphragm can be rigidly clamped between the back plate and cap of the microphone; thus giving the very best possible connection between the carbon diaphragm and the metal work of the transmitter head.

Some people claim that metal diaphragms do not break. This is true, but if poked with a pencil, they become dented and, of course, will then give bad service; whereas, if a carbon diaphragm is broken, it is but the work of a few moments to replace it with a new one and then your telephone is as good as new.

IN PURCHASING APPARATUS of any kind, either telephones or switchboards, it is always best to buy good material of some reliable firm, not necessarily the largest. Any good reliable company is perfectly willing to sell telephones to responsible parties on thirty days' approval. Telephones should be given a rigid test to see that they come up to the manufacturer's guarantee and should be inspected as to the general construction and their lasting qualities, etc. Good common sense and judgment is about the best thing that the author can recommend to go by in forming your opinion as to the different ad-

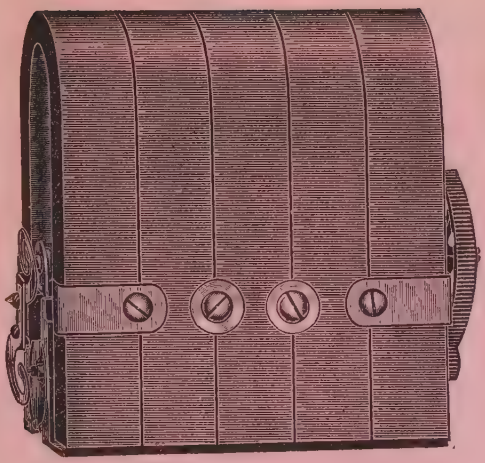
vantages of one form of construction over another as claimed by the different manufacturers.

It is with telephones, as with anything else, they can be bought at all prices, but a poor telephone is not worth anything, as it will not talk or ring and it certainly is of no value for any other purpose.

Generally speaking, it is best to start out with bridging telephones of a higher resistance winding on the ringers, than is thought necessary to operate the number of telephones started out with, as it is almost an invariable rule that lines starting out with say 10 or 12 instruments, with no apparent possibility of ever having any more instruments, soon have, almost double and sometimes three times as many on them, as their original builders ever expected. When people once have a telephone, they will never consent to be without it. Such has been the history of the telephone business.

Success in the telephone business, as in everything else, requires pluck and an abiding faith in the stability and future of the business, and good business judgment in the purchase of instruments and supplies and its general management.

Beware of telephone agents, representing manufacturers, who use high sounding terms and phrases that are meaningless and cannot be understood by the purchaser. It does not require false representations or high sounding phrases to sell good telephones. The truth is good enough and can be spoken in plain, simple language that can be readily understood. Also beware of the people who are going to give you great bargains in telephones. An honest, straight article, no matter what it is, is worth a certain price, and it will not be sold below that price. As the old saying goes, "You cannot get something for nothing," and whenever a man claims to "give you something for nothing," he is acting unnaturally and should be watched. That man is trying to take advantage of human nature.



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We guarantee this to be the ***strongest telephone generator*** in the world.

We guarantee it to ring twenty.....1000 Ohm Telephones
" " " " thirty-two. .....1600 " "
" " " " fifty ....2500 " "
" " " " seventy .....3500 " "

Through a line resistance of 1000 Ohms, or half above number of phones through 2000 Ohms, or twice above number of phones through 500 Ohms.

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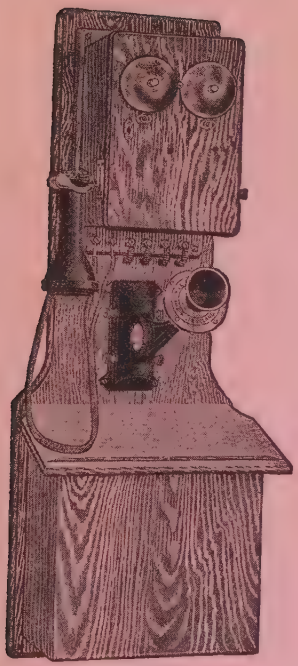

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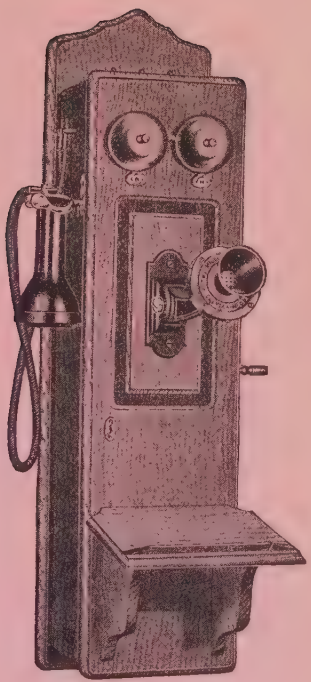

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THE above illustrations show two of our most popular styles of Telephones. Furnished in either Oak or Walnut, with either our Standard Three Bar or our "Jumbo" Generator. Table showing number of phones guaranteed to ring loudly and clearly on one line :

Resistance of Ringer.	With Standard Three Bar Generator.	With "Jumbo" Generator.
1000 Ohms Bridged	10 Telephones	20 Telephones
1600 " "	16 "	32 "
2500 " "	25 "	50 "
3500 " "	35 "	70 "

Above table based on line resistance of 1000 Ohms.

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80 to 86 Seneca Street, CLEVELAND, OHIO.

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We sell all Telephones on *thirty days* approval, and *guarantee* them for *five years*. We don't want your money till you are satisfied that *our telephones are the best you can buy*.

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